Symposium held at AFS 134th Annual Meeting, Madison WI, August 2004

Symposium Title:

Sturgeon Population Rehabilitation and Management

Tuesday August 24, 8:00 AM – Noon
Wednesday August 25, 8:00 AM – 5:20 PM

Organizers:

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Description:

Sturgeon species around the world have been the subject of growing interest over the last 20 years due to their often endangered or threatened status, the rising demand for caviar, and because of their interesting life history. Over the last several decades various state and national agencies and institutions from throughout the northern hemisphere have initiated extensive sturgeon stock assessment efforts and in some cases have initiated long term sturgeon stock rehabilitation programs. The objective of the symposium "Sturgeon Population Rehabilitation and Management" was to examine and discuss the status and results of these pioneering efforts to rehabilitate and subsequently manage sturgeon stocks. Case studies from both North America and Eurasia were discussed to provide insight into a variety of rehabilitation and management issues including: planning strategies, stocking and assessment strategies, gamete collection procedures and genetic conservation, behavior of stocked fish, habitat management and rehabilitation, fishery development and management, and public involvement and education.

Moderators:

Tuesday August 24

8:00 - 9:40 AM (to the break)	Ron Bruch
10:20 - 11:40 AM (to lunch)	Fred Binkowski

Wednesday August 25

8:00 - 9:40 AM (to the break)	Serge Doroshov
10:20 - 11:40 AM (to lunch)	Joern Gessner
1:30-3:00 PM (to the break)	Ted Smith
3:40-5:20 (to the finish)	Ron Bruch

Speakers and Topics

Tuesday August 24

The past and present of sturgeon management and rehabilitation
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Historic and archaeological records indicate that sturgeons were abundant before the 19th century. By the end of the 19th century, caviar fisheries and industrial pollution severely depleted sturgeon stocks. The impact of humans increased during the 20th century, when the large hydropower dams on major spawning rivers hampered recruitment and brought some populations and species to extinction. Baer and Danilevskii (1860) formulated the first principles of sturgeon management, such as the protection of natural river flow and prevention of overfishing. However, the practical implementation of management progressed slowly while the impact of humans increased. We will revisit the history of sturgeon management, including the early period of artificial propagation for stock enhancement in North America and Europe, the large-scale hatchery stocking and stock management programs in the USSR, and the current approaches to management and rehabilitation of sturgeon stocks. We will discuss the needs of research in sturgeon biology and the development of a holistic approach to the management and rehabilitation of sturgeon stocks.

Creation of Lake Sturgeon Spawning Habitat in the Detroit River
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Overexploitation, reduced access to spawning sites (dam construction), and destruction of habitat have reduced lake sturgeon (Acipenser fulvescens) in the Great Lakes to less than 1% of their former abundance. In Michigan, they are threatened with extinction. In the Detroit River between Lakes St. Clair and Erie, four years of set-line fishing captured only 86 lake sturgeon. Only two of nine reputed, historic spawning sites in that river have enough void space to safely incubate lake sturgeon eggs and no sturgeon spawn there. Restoration of lake sturgeon in the Detroit River is limited by available spawning substrate. In 2001, lake sturgeon spawned at a man-made (coal cinder) site in this river. In 2002, a Great Lakes Coastal Restoration Grant and the Great Lakes Fishery Trust provided over $420,000 through Michigan Sea Grant to enhance lake sturgeon spawning habitat. In 2003, pre-construction assessment revealed that no lake sturgeon used the proposed project site. In 2004, we constructed three lake sturgeon spawning beds, consisting of 8-16 inch broken limestone, 4-12 inch metamorphic cobble and gravel, and 1-4 inch coal cinders. Each bed is 4000 sq. ft by 2 ft thick, and located at 22-28 ft depth in fast (2-3 ft/s) water velocity. Telemetry of lake sturgeon that spawn on the new beds in 2005 and 2006 will show what population(s) of lake sturgeon were enhanced.

Availability of Potential Gulf Sturgeon Spawning Habitat in Northwest Florida and Southeast Alabama River Systems
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The availability of potential Gulf sturgeon spawning habitat was documented in northwest Florida and southeast Alabama river systems. Potential spawning sites were identified in six river systems by visually characterizing habitats that appear similar to known Gulf sturgeon spawning areas. Each river was floated downstream from the first obstruction that would (in normal years) most likely be the upper reach for Gulf sturgeon distribution,

Locations of each site were recorded with a G.P.S. unit and photographed. Physical features were documented. One hundred and fifty-two sites, totaling 93 km, were identified as having characteristics similar to documented Gulf sturgeon spawning habitat. Potential spawning sites ranged from small individual sites, less than 30 m in length, to numerous sites within a longer river reach exceeding 7 km. Nearly 90% of the available Gulf sturgeon spawning habitat was located in Alabama.

Breaking Barriers: Facilitating Adult Sturgeon Passage, towards Population Rehabilitation

J.D. Webber, S.N. Chun, E.K. Anderson, M.L. Kavvas, M.M. Rotondo, R. Churchwell, R. Padilla, C. Wilkinson, and J.J. Cech, Jr*.
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Upstream passage of sturgeon past barriers such as dams has become a concern of natural resource managers in California. However, little is known about the swimming abilities of adult sturgeon, regarding fish ladders. Wild, adult white sturgeon, Acipenser transmontanus (n = 25, 135 – 198 cm TL), were swum in a variable-speed flume (24.4 m long, 2.1 m wide, and 1.4 m deep) to evaluate swimming behavior around simulated fish-ladder-type partial barriers. Four barrier types were tested at three velocities. Faster velocities (0.76 – 1.07 m/s), in general, cued fish to swim upstream, sooner. Among the barrier types, percentages of successful passage were mixed, with no statistically significant pattern detected. Mean tail-beat frequency increased significantly with water velocity ($p < 0.05$), with the highest frequencies measured (33 strokes/min) in the high-velocity sections of the flume (2.02 – 2.52 m/s), adjacent to barriers. Sturgeon were able to pass adjacent to barriers where water velocities reached 2.52 m/s by swimming in bursts, followed by a resting and recovery period in slower moving water. This information will likely be valuable in designing sturgeon-appropriate fish passage facilities, towards the rehabilitation of sturgeon populations. Research funded by the California Department of Water Resources and California Bay-Delta Authority (CALFED).

Size and Seawater Tolerance Affect the Swimming Performance of Juvenile Green Sturgeon (Acipenser medirostris)

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Several smolting salmonids have shown decreases in maximum aerobic swimming performance (critical swimming velocity, Ucrit), compared with (size-extrapolated) freshwater parr. Green sturgeon are also fully anadromous, and they exhibit a similar downstream migration and seawater transition as juveniles. We tested our hypothesis that they decrease Ucrit during this transition. Swimming experiments were conducted concurrently with salinity tolerance studies showing that fish were increasingly tolerant of full-strength sea water (33 ppt) during the ages (73-177 days post hatch) and sizes (15-45 cm TL) studied, at 19ºC. Juvenile green sturgeon that had not reached seawater tolerance had a positive relationship ($p<.0007$, $n= 59$) between Ucrit (cm/s) and TL. However, sturgeon that had reached seawater tolerance (>30.9 cm TL), had a negative relationship between Ucrit and TL ($p<.029$, $n=19$), presumably facilitating this downstream migration to the ocean via their decreased ability to resist strong river currents. The similarity of this Ucrit – seawater tolerance relationship to that seen in smolting salmonids probably indicates a repeated evolutionary emergence of this pattern in juvenile, anadromous fishes. We thank the Anadromous Fish Restoration Program (USFWS & USBR), California Bay-Delta Authority (CALFED), and Marin Rod and Gun Club for funding, and the Yurok Tribe for brood fish.

Impacts of a Non-Habituating Stress Response in Green Sturgeon: Energetic Consequences

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Metabolic scope for activity (MSA), critical swimming velocity (Ucrit), and liver glycogen levels were measured in green sturgeon (age 0+) exposed to two stressors daily (1000 and 1600 h) for 28 consecutive days and compared to unstressed fish in an effort to measure the “cost” of chronic stress. Fish were exposed to a randomized order of acute stressors: a 5-min chasing stressor, a 10-min water depth reduction stressor, or a 5-min confinement stressor. The acute cortisol response to each individual stressor did not result in habituation of the acute stress response, as measured in 7-day intervals. Oxygen consumption and Ucrit were measured using a Brett-type swimming-tunnel respirometer. Exposure to the chronic stress regime resulted in a 25% reduction of MSA due to a significantly increased maintenance metabolic rate (0.27 ± 0.01 vs. 0.19 ± 0.02 mg O2 /h/g: chronic vs. control fish,

respectively). A 50% reduction in liver glycogen levels was also measured in chronically stressed fish, however there was no difference in Ucrit between treatments. We conclude that our chronic stress regime resulted in a significant maintenance cost to green sturgeon, without decreasing their swimming performance. We thank the AFRP (USFWS & USBR), CALFED, and the Yurok Tribe.

Drift Dynamics of Larval Shovelnose Sturgeon in a Side Channel of the Upper Missouri River

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The goal of this study was to obtain an understanding of larval shovelnose sturgeon drift dynamics in the upper Missouri River. The specific objectives were: (1) to quantify the vertical distribution of larvae in the water column, (2) to determine drift rates of larvae related to hydraulic conditions, and (3) to provide initial considerations for modeling larval sturgeon drift dynamics in the upper Missouri River. Larval shovelnose sturgeon were released at the head of a 1,400-m-long side channel of the Missouri River on two dates (day 1, 40,000 larvae released, age-0 and age-1-day-old; day 2, 30,000 larvae released, age-0 through age-2-day-old). The larvae were sampled continuously for up to 90-min post-release with nets positioned on the surface and bottom at locations 100-m, 500-m, 900-m, and 1,300-m downstream from the release point. Larvae exhibited a strong tendency to drift near the bottom. The range of time that larvae were sampled in the drift increased from upstream to downstream sampling locations. The mean drift velocity of larvae was significantly slower than mean water column velocity; however, larval drift velocity was similar to mean near-bottom current velocity. Results from this initial field study suggest that hydraulic modeling of drift rates and drift duration of age-0 through age-2-day-old larval shovelnose sturgeon should be based on near-bottom water velocities.

Movements of Lake Sturgeon in the Huron/Erie Corridor

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Lake sturgeon (Acipenser fulvescens) movement patterns are complex not only due to differences between lake basins where they reside, but also habitats required for spawning, resting, foraging, and over-wintering. In 1994 researchers from federal, state and provincial governments working closely with universities and commercial fishers began an aggressive tagging and telemetry program to address management concerns and better understand the movement patterns of sturgeon captured from Lake Huron through western Lake Erie. A total of 1,967 sturgeon were captured, tagged and released. Ninety-seven tag recoveries were recorded from assessment, sport fishing, and commercial fishing. Tag recoveries generally documented movement patterns within a regional area of a system but also showed movement patterns between systems. Telemetry studies from 1997—2000 (N. Channel St. Clair R.), 2000—2001 (Detroit River), and 2002—2004 (headwaters St. Clair R.) tracked adult spawning lake sturgeon utilizing the only known spawning reefs found in the Huron/Erie Corridor. Sturgeon had unrestricted movement between systems, yet during summer most sturgeon were densely aggregated in a small geographic area of Lake St. Clair.

Lake Sturgeon Rehabilitation in Lake Michigan, the Milwaukee River Experience

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The lake sturgeon Acipenser fulvescens occurs in Wisconsin in the Mississippi, Lake Michigan and Lake Superior drainage basins. It is common in the Menominee River, the lower Wolf River, Lakes Poygan and Winnebago, Lake Wisconsin, the St. Croix River to Gordon Dam, Namekagon River below Trego Dam, and the Chippewa and Flambeau Rivers. In Lake Michigan it is uncommon to rare. Because Wisconsin has given the lake sturgeon “watch” status, the Department of Natural Resources is committed to rehabilitation of lake sturgeon in areas where it has been extirpated. As part of the rehabilitation effort, the Milwaukee and Manitowoc Rivers were chosen to receive annual stocking of lake sturgeon in an effort to reestablish populations in these two tributaries. In the Milwaukee River, initial plans called for the annual stocking of 2,800 fingerlings, 100 yearlings and 100,000 larvae of the Lake Winnebago strain. Transfers of adult fish from the Wolf River would supplement the stocking program. PIT tags and radio tagging will aid in identifying lake sturgeon population and life history needs, identify critical habitat and barriers to migration. This rehabilitation is in the early stages, however progress to date will be reported.

Tennessee Lake Sturgeon Restoration Project
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Lake sturgeon were biologically extirpated from the Tennessee River portion of their native range approximately 50 years ago by poor water quality, overexploitation, and habitat alteration. Measures were taken to improve water quality and habitat alteration in 1991 when Tennessee Valley Authority (TVA) began providing minimum flows and aerating discharges from 16 hydroelectric dams in the upper Tennessee River system. Dramatic biological resurgence in the French Broad River downstream from Douglas Dam by 1994 stimulated the creation of a multi-agency lake sturgeon restoration team in 1995, whose goal is the establishment of self-sustaining lake sturgeon populations and eventually a recreational fishery managed by the Tennessee Wildlife Resources Agency (TWRA). Each spring since 1998, fertilized sturgeon eggs provided by Wisconsin Department of Natural Resources (WDNR) are hatched at the USFWS Warm Springs National Fish Hatchery (GA). The young fish are then reared at three national fish hatcheries and the Tennessee Aquarium Research Institute (TNARI). Since the initial public release of lake sturgeon in July, 2000, over 21,000 lake sturgeon have been stocked into the French Broad, Holston, and upper Tennessee rivers in East Tennessee. Recaptures and fishermen reports indicate healthy sturgeon dispersing throughout the upper Tennessee River system.

Wednesday August 25

Lake sturgeon (Acipenser fulvescens) on the Menominee Indian Reservation: an effort towards co-management and population restoration
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The lake sturgeon (Acipenser fulvescens)is a species of cultural significance to the Menominee Nation, a Native American tribe indigenous to northeast Wisconsin. Lake sturgeon in the Lake Winnebago system historically migrated up the Wolf River to spawn at Keshena Falls, within the current boundaries of the Menominee Reservation where, each spring, the Menominee People gathered at Keshena Falls to harvest lake sturgeon. The construction of two dams on the Wolf River downstream from Keshena Falls in the late nineteeth and early twentieth centuries contributed to extirpation of this species on the Menominee Reservation. The general public has had the opportunity to harvest lake sturgeon from Lake Winnebago during the winter spear fishery since 1932. Those who participate within the fishery feel strongly about the lake sturgeon resource as do the Menominee People. Cooperation among multiple resource management agencies and the public was necessary to address the interests of both groups and at the same time ensure protection of the Winnebago lake sturgeon population. In 1993, tribal, state, and federal representatives developed a plan to reintroduce lake sturgeon to the Menominee Reservation. The Menominee Lake Sturgeon Enhancement Committee identified common lake sturgeon restoration goals, objectives, and management strategies. This report will discuss lake sturgeon management and the preliminary results of habitat requirements, seasonal movements, stocking, dispersal, and numbers of lake sturgeon reintroduced into Menominee Reservation waters.

Lake sturgeon restoration in Oneida Lake, New York: stocking, habitat use, and life in the fast lane
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Oneida Lake is one of several waters in New York State included in a lake sturgeon restoration program initiated in 1995. To date, 7,000 hatchery-reared lake sturgeon have been stocked into Oneida Lake and data from over 400 fish sampled since 1996 indicate a fast-growing and healthy population. Length-at-age data show growth rates of 116 mm/year through age 8, faster than other systems for which data are available. Similarly, length-weight relationships show lake sturgeon in Oneida Lake to be in excellent condition, with the largest individual from our samples weighing 16.9 kg at a length of 131.5 cm. Several age-8 males readily released sperm during spring 2003 sampling, providing further evidence that conditions in Oneida Lake are very favorable. A habitat-specific gill net survey has produced overall catch rates of 0.3 sturgeon/hour over 2 years, with highest catches observed over sand and shoal

substrates as compared to silt and mud bottoms. Diet samples indicate that amphipods, snails and zebra mussels are the most important foods of sturgeon in Oneida Lake and availability of these taxa is highest in sand and shoal habitats. These studies should assist in identification of habitats where sturgeon stocking might be most successful.

Status and Management of Lake Sturgeon in the Huron/Erie Corridor

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Management of lake sturgeon in the Great Lakes is limited by inadequate scientific information about lake sturgeon (Acipenser fulvescens) stocks, numbers, movements, recruitment, and the effects of size limits, particularly in the 100-mile channel connecting Lakes Huron and Erie. In Michigan, lake sturgeon are listed as threatened with extinction. In Ontario, lake sturgeon are not listed as threatened or endangered. In Michigan waters of the St. Clair River, anglers may possess one 42-50 inch lake sturgeon per year. In Ontario waters of that river, anglers may possess one lake sturgeon of any size per day. Since 1999, in Michigan waters of the Detroit River, it has been unlawful to possess a lake sturgeon. In Ontario waters of that river, anglers are permitted to possess one lake sturgeon of any size per day. Resolution of these disparate catch regulations in contiguous Michigan and Ontario waters caused fishery managers to request this summary of the status of lake sturgeon in this Corridor. In it, we summarize the available scientific information about lake sturgeon that is relevant to science-based management of lake sturgeon in these international waters.

Lake Sturgeon Rehabilitation in Western Lake Superior

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Lake sturgeon Acipenser fulvescens in western Lake Superior historically spawned in the St. Louis River, but were extirpated during the early 1900s due to the combined effects of overexploitation and degraded water quality. Following control of exploitation and improvements in water quality, the Wisconsin and Minnesota Departments of Natural Resources attempted to reestablish a spawning lake sturgeon population in the St. Louis River by releasing 762,000 fry, 143,000 fingerlings and 500 yearlings. The fish were released from 1983 to 2000 and represented 14 different year classes. Stocked lake sturgeon distribution and movement in western Lake Superior was determined by the abundance of fish in assessment nets and the recapture of marked fish. High survival of stocked fish has dramatically increased lake sturgeon abundance in western Lake Superior. Fish were generally found in less than 30 meters of water and ranged along the 65 km of Wisconsin shoreline from the mouth of the St. Louis River to Bark Point. Two decades after the rehabilitation program began stocked lake sturgeon have established a home area in western Lake Superior and adults have started returning to the St. Louis River spawning grounds.

Post stocking behavior of lake sturgeon

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A critical need associated with sturgeon rehabilitation is to have better understanding of post-stocking behavior and movement of fish, as well as the effect of age, season (temperature), and strains. Fingerlings, yearlings, and subadult lake sturgeon from the upper Fox and Wolf Rivers (of the Winnebago System) were stocked in June, August, November, and December. All stocked fish were raised from eggs under hatchery conditions. Fish were pit tagged 30-60 days prior to release. Tag retention was greater than 95%. Fifty-three fingerlings and yearlings were surgically implanted with radio transmitters, 1.0 g to 11.0 g. Nine subadults were fitted with 40 gram external tags. Tag life for fingerlings was 20-30 days, 160-200 days for yearlings, and 700 days for subadults. Radio telemetry tracking was conducted for 8-20 hours per day the first 5 days following release. Subsequent tracking was conducted bi-weekly using an airplane. In June and August, the primary behavioral response was rapid distribution and movement down stream. Following November and December stocking events, the behavioral response for all ages was slow distribution and limited movement down stream. After one year 70% of the subadults are still in the river system, over wintering in deep holes 15-25 feet.

Sturgeon Restoration and Management Efforts in Missouri: Two Decades of Experience in the Show-Me State

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Lake, pallid, and shovelnose sturgeon all occur in Missouri. Shovelnose sturgeon populations appear to be fairly stable, allowing for commercial harvest. However, lake sturgeon populations were reduced in the early 1900's due to commercial over-harvest, and they are listed as threatened in the state. Pallid sturgeon populations were negatively affected by habitat alteration in Missouri related to channelization and bank stabilization for navigation, and they are now federally endangered. The Missouri Department of Conservation (MDC) has an active restoration program for both lake and pallid sturgeon. Hatchery propagation efforts have resulted in the stocking of 200,000 lake sturgeon in the Missouri and Mississippi rivers during the past twenty years within the state. Additionally, 10,000 pallid sturgeon have been stocked in the Missouri River during the past decade. Recently, MDC initiated a sturgeon monitoring program on both the Missouri and Mississippi rivers to track population trends of commercially important shovelnose sturgeon, and examine the success of the stocking programs of both lake and pallid sturgeon. Finally, habitat restoration efforts are underway on both the Mississippi and Missouri rivers that will hopefully provide additional habitat for these species of concern. Results of these efforts will be summarized in relation to the successes and failures of these programs.

Management of lake sturgeon on the Lake Winnebago System, Wisconsin

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The Winnebago System in east central Wisconsin is home to the largest remaining lake sturgeon stock in North America. This stock has supported a recreational winter spear fishery since 1931, currently producing an average of over 1000 sturgeon (20000 kg) per year during the 2 to 16 day season. The management program is made up of 4 key components: population and harvest assessment, habitat development and enhancement, law enforcement, and public involvement. Assessments are conducted annually to provide estimates of spawning stock densities, and direct enumeration of harvest. Spawning and nursery habitat has been regularly developed on private and public lands for the last 40+ years. A progressive law enforcement program includes utilization of citizen volunteers to patrol spawning sites during the vulnerable spring spawning period, and an active Citizens Advisory Committee assists in the development of needed regulation and management program changes. This management model has provided the tools necessary to effectively address issues of growth in the fishery and overexploitaiton of the adult female stock in the 1990's. The program currently manages harvest through a harvest cap system that limits the number of sturgeon harvested while maintaining an open fishery with no limit on spearing license sales.

Managing lake sturgeon (Acipenser fulvescens): viewing resources from a human dimensions perspective

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Wildlife viewing is a non-consumptive recreation activity that includes observing, feeding or photographing wildlife. There are few economic estimates for wildlife viewing of aquatic species and this is the first study to estimate the economic impact of a sturgeon viewer population. Each spring lake sturgeon spawn along Lake Winnebago tributary rivers, drawing numbers of people to view this event. Little is known about the viewers, how they value sturgeon and their thoughts about the management of the resource. In the spring of 2002, data were collected using a random stratified survey (similar to an angling creel survey) at three major sturgeon viewing areas. Results of this study indicate the average sturgeon viewer is a Wisconsin resident, 49 years old, white male with post-high school education, who has been viewing for 13 years and has a moderate income. The 2002 sturgeon viewer population was estimated at 3,176 viewers resulting in an economic impact of $344,198. Eighty percent of the viewers support or strongly support harvest regulation options that would protect the sturgeon population. Results such as these provide values which help justify/support restoration and/or management actions and recognizes the values associated with nonconsumptive use of sturgeon.

Pallid Sturgeon Status and Recovery Efforts in the Missouri and Yellowstone Rivers, Montana

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One of the few pure pallid sturgeon populations is in the Missouri River from Fort Peck Dam to Lake Sakakawea, and the lower Yellowstone River. This population is composed of large, old-aged individuals with no evidence of recruitment. Two remedial actions were proposed to prevent extirpation: (1) modified dam operations to rehabilitate habitats and provide spawning cues; and (2) a stocking program to augment the population. However, abundances of wild pallid sturgeon were not estimated since 1995. I estimated abundances during 1991-2003. My results show a decline during 1991-2003, with an abundance estimate of 151 (95% CI 265-89) for 2003. The rate of decline indicates that this population will be extirpated during 2018. Proposed modified dam operations have yet to begin; habitats must be rehabilitated immediately if wild pallid sturgeon are to contribute to future generations. Stocking hatchery-reared pallid sturgeon continues to be the focus of recovery efforts. The stocking plan calls for a standing population of 1,700 adult pallid sturgeon. This is unlikely to be achieved, as about 9,000 hatchery-reared pallid sturgeon must be stocked annually; a total of 8,644 were stocked during 1998-2003. All hatchery-reared pallid sturgeon produced must be stocked into the wild, and habitats must be rehabilitated immediately if pallid sturgeon are to persist.

Stock Enhancement of Shortnose Sturgeon in the Southern US: Lessons Learned

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A federal/state program evaluated use of hatchery produced shortnose sturgeon (Acipenser brevirostrum) as a management tool for supplementation/restoration of this endangered species. Using wild broodstock, 97,483 sturgeon of various ages was produced and stocked into the Savannah River, GA/SC during 1985-1992. Of these, 18,213 (18.7%) were marked in some manner. Fish used to assess impacts were obtained from directed sampling and from commercial fisheries bycatch. During 1997-2000, 10% of the adult shortnose sturgeon population in the Savannah River was identifiable as hatchery reared fish (expanded to 38.7% based on tag loss estimates). Beginning 1995, stocked fish began to be captured in non-target rivers, especially the nearby Ogeechee (GA) and Edisto (SC) Rivers. Contribution to the Ogeechee population remains substantial while stocked fish appear to have colonized the Edisto, reproduced, and now form a new population. The stocked fish behaved similarly to their wild counterparts and the data clearly show that hatchery-origin shortnose sturgeon can make significant contributions to populations. Issues related to long-term identification, unequal contributions from different stocked groups, and how to imprint fish on target rivers need to be addressed. Research on these topics is encouraged to further refine the use of stocked fish as a potential management tool.

A Plan for the Restoration of a Depleted Population of Shortnose Sturgeon in the Ogeechee River, Georgia, USA

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Several years of data, including age distribution and CPUE, indicate that the shortnose sturgeon population in the Ogeechee River, GA is small and declining, and that recruitment has not been successful in several years. The population is comprised partially (up to 50%) of cultured fish that were originally stocked into the nearby Savannah River during 1985-1992. Efforts are underway to: (1) gather records that might suggest historical abundance and distribution of sturgeon in the Ogeechee River; (2) investigate potential causes (e.g., water quality degradation, siltation, altered aquifer level) for the apparent recruitment failure; (3) apply telemetry techniques to determine habitats presently utilized; (4) explore the ramifications of supporting the population through stocking artificially propagated fish; and, (5) disseminate information about the critical situation regarding survival of the population, both to the public and throughout the agencies responsible for managing shortnose sturgeon. To address these issues, the Ogeechee River Shortnose Sturgeon Working Group was formed. It is comprised of representatives from multiple state and federal agencies, as well as universities and NGO's. The approach that has been designed to respond to this complex situation may be useful as a model that can be applied in other systems.

Dilemma on the Kootenai River - The Risk of Extinction or When Does the Hatchery Become the Best Option?

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The Kootenai River white sturgeon is endangered. A Recovery Plan included 1) mitigation of flows for spawning and early life rearing 2) conservation aquaculture to prevent extinction and sustain year classes, a short-term measure as flow mitigation for wild fish developed. After eight years of flow mitigation and intensive monitoring it became apparent recovery needs were more complex. Habitat is a concern, spawning location did not appear suitable for adequate survival of eggs and larvae. Recruitment of wild fish was low and survival of hatchery sturgeon high. Assessment of sturgeon demographics provided evidence the wild population would be extinct within three decades and the population would be comprised almost exclusively of hatchery fish. Managers are faced with a contentious dilemma of elevating the hatchery program; taking a higher proportion of wild spawners, escalating the number of hatchery releases, which could result in increased risk of inbreeding depression, loss of genetic diversity, genetic swamping, long term domestication, and intra- specific competition with wild recruits. Without significant hatchery intervention the population could become a museum piece with no management to benefit anglers. Risks must be considered, we propose some compromises that may ease the intrusion of hatchery fish and provide management options.

How much is enough? Assessing stock limitation in empirical white sturgeon populations in the US and Canada

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White sturgeon (Acipenser transmontanus) inhabit the Pacific Coast of North America from central California, north to the Gulf of Alaska, as well as many larger tributary systems and their subbasins throughout this latitudinal range. White sturgeon populations have been negatively affected throughout their range by fragmentation, habitat loss and degradation, and overharvest. Successful recovery activities for white sturgeon require remnant populations with adequate genetic and demographic restoration potential. However, peripheral populations, those in upper reaches of Pacific Coast River systems, appear to currently lack the ability to respond favorably through natural production. This trend brings into question the restoration potential of such populations. Because white sturgeon are long-lived and iteroparous, and contain hundreds to several thousand individuals in remnant populations, some mangers have dismissed stock size as a main limitation in various white sturgeon populations. However, given the extent and magnitude of ecological alteration in their native habitats, larger populations than previously expected may be needed to restore populations through natural production. Empirical population abundance estimates, habitat characteristics, inland distance, and numbers of downstream impoundments are evaluated and compared across recruiting and non-recruiting populations to assess possible threshold requirements for natural recruitment of white sturgeon in the US and Canada.

A Riparian Habitat Hypothesis for Successful Reproduction of White Sturgeon (*Acipenser transmontanus)*

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White sturgeon (*Acipenser transmontanus*) has recruitment failure or severe inter-annual variability in much of its range. Exceptions are Columbia River below Bonneville Dam, Snake River below Hells Canyon Dam, lower Fraser River, and Sacramento River. Once-continuous populations now isolated by natural barriers or dams often have not reproduced successfully, despite successful spawning events, since rivers were impounded or flows regulated. Research has not adequately explained recruitment failures or why certain populations are successful. This paper proposes that submerged riparian habitat during seasonal high water is needed for early development. Where recruitment is successful, channels are complex and floodable riparian vegetation or rocky substrate is abundant. There, spawning occurs in turbulent zones upstream (1-5 km) of seasonally submerged riparian habitat, eggs can disperse into inundated habitat and adhere to newly wetted surfaces for incubation, yolk-sac larvae can move to riparian crevices for pre-feeding development, feeding larvae have food-rich flooded habitat for early growth, and larvae can transition to juveniles as water recedes to permanent channels. Such habitat is lacking where recruitment is low and present only in high-flow years where recruitment is sporadic. These observations suggest that

management should rehabilitate riparian zones and provide high river flows during spawning to stimulate natural recruitment.

Sturgeon rehabilitation in the North and Baltic Seas

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A sturgeon rehabilitation programme has been carried out in Germany with Federal support since 1996, mainly focusing on the European Atlantic sturgeon as target species for North and Baltic Seas. During the first phase the main aims were the verification of the species status in its historic range, to build up a brood-stock of the species, to determine the suitability of available habitat for early life stages, and to genetically characterize the potential donor and the historic recipient populations. Genetic and morphological evidence revealed that the Baltic sturgeon is a representative of the Haplotype A of A. oxyrinchus whereas A. sturio recently ranged in the North Sea, European Atlantic and the Mediterranean as well as the Black Sea. Therefore, sturgeon rehabilitation measures in the North Sea tributaries will have to use A. sturio of French origin - resembling the historic genotype in this area. For the Baltic, rehabilitation measures must focus upon A. oxyrinchus for which a brood-stock is currently developed. The experimental release of juveniles will initiate telemetry and tagging studies to verify habitat utilization. Thus leading to a determination of carrying capacity and restoration requirements for the available habitat and to perform a risk assessment.

The status of sturgeon rehabilitation programs in Italy

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Three species of sturgeon (Acipenser sturio, Huso huso and A. naccarii) were once present in Italy, but only the endemic Adriatic sturgeon, A. naccarii, is currently artificially reproduced from a original broodstock caught in the wild in the seventies, and juveniles are utilized by various partners for rehabilitation programs. Restocking actions have been carried out since 1989 mainly by Regione Lombardia: over 250.000 animals ranging from 2,5 to 80 cm, were released in rivers tributaries of the Po river, the main river of Italy. To evaluate the genetic diversity and to recognize the released animals caught in the wild, the genetic characterization of the parental broodstock was carried out by Ferrara University. Studies on tolerance and adaptability to salinity were conducted by Enel and Tor Vergata University of Rome. Telemetry techniques are utilized at present by CESI and Provincia di Piacenza to investigate the movements of F1 subjects reintroduced in the Po river. Similar experiences are carried out by Provincia di Venezia in the river Piave and by Provincia di Verona in the river Adige. In the close future a fish passage, specifically studied for sturgeon, will be implemented at the Isola Serafini dam, at the middle of the course of the river Po, with the co-operation of WSCS (World Sturgeon Conservation Society).

The Azov Sea Sturgeon Recovery Program

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The natural propagation of sturgeon in the Azov Sea basin are hampered by the rivers flow regulations. As a result, for the past 25 years Acipenser gueldenstaedtii, A. stellatus and Huso huso stocks are sustained only by hatchery stocking (up to 30 mln. juveniles annually). The simplified stocking strategy was aimed solely at the release of a large number of juveniles, utilizing for breeding only the most mature early spring run spawners . For the large-scale stocking few breeders were used. From 1996 to 2003 the number of sturgeon females decreased from 1029 to 81. The analysis of protein polymorphism reveals significant changes in the stock genetic composition of the Azov sturgeon related to the hatchery practices and stocking allopatric Caspian Sea populations. Traditional technology of the artificial reproduction appeares to be ineffective under existing ecological conditions. Accordingly, the following recovery measures should be undertaken: - raising of the existing fish-passes efficiency; - designing of new types of artificial spawning sites; - development of protocols for maximizing the captive stocks heterogeneity, wild-caught sturgeon transferring into captivity, release of farmed stock to the wild; - employment of non-traumatic (ultrasonic) method for sexing of juveniles; - extending of timing, various sites and size juveniles release.

The Expanding World of Sturgeon Conservation Genetics

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The worsening status of many of the world's sturgeon populations, together with the development and refinement of molecular tools, has led to a flourish of genetic studies of these fishes centered around their conservation. Recent studies have focused on first defining or elaborating on stock structure and gene flow, resolving taxonomic questions and identifying sturgeon food products through forensics, assisting culture and assessing stocking effects, and even reconstructing a natural trans-Atlantic colonization. Molecular tools continue to advance; however, microsatellite analysis, which has become the predominant molecular technique for fishes, is complicated in sturgeons by their polyploidy. A recent finding by Quattro that estimated effective population sizes for some shortnose sturgeon Acipenser brevirostrum populations were much larger than census sizes was attributed to a possible genetic storage effect emanating from their demographic attributes. If so, then it remains to be seen if this potential genetic buffer against inbreeding effects also holds true for other acipenserids. Various examples of the past use of molecular tools in the conservation of sturgeon species, their limitations, unresolved issues, and future directions will be presented.