Regulatory Options
for the
Commercial Rearing
of
Lake Sturgeon

Report to the Legislature

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Departments of Agriculture, Trade & Consumer Protection and Natural Resources

Although five options are listed for the State Legislature to consider, The Regulatory Options for the Commercial Rearing of Lake Sturgeon reveals two distinct philosophies toward the rearing of lake sturgeon by private aquaculture in Wisconsin. The first is primarily supported by the Wisconsin Aquaculture Association (WAA) and intends to end the prohibition on lake sturgeon rearing by private aquaculture. The other is supported by the Department of Natural Resources (DNR) and the Sturgeon Management Assessment Team (SMAT) and advocates keeping the current prohibition in place, but involves private aquaculture in the propagation of the species for research and rehabilitation purposes only.

The WAA believes lake sturgeon are a marketable and potentially lucrative fish that could and should be reared by private aquaculture in Wisconsin. The caviar and flesh demand for varieties of sturgeon, plus the market for live fish, is growing in North America due to Eastern European and Russian overharvest and decimation of the species. Many years have passed since the State Legislature prohibited the commercial marketing and sale of lake sturgeon in Wisconsin, and since that time, aquaculture techniques have developed and advanced making aquaculture feasible and rational. Also, of the other states and provinces surveyed in 1998, 9 of the 15 currently allow the legal sale and distribution by private commercial operations of lake sturgeon flesh and caviar. Finally, since tribes are allowed to rear lake sturgeon for monetary gain, the aquaculture industry does not think it should be excluded from this arrangement.

The Department of Natural Resources and the Sturgeon Management Assessment Team believe, and the lake sturgeon aquaculture research conducted over the last 20 years in Wisconsin illustrates, lake sturgeon as a species does not lend itself very well to aquaculture production due to a slow growth rate and very late sexual maturation. The DNR and the Sturgeon Management Assessment Team are opposed to any private aquaculture rearing of lake sturgeon that has an ultimate goal of selling flesh, caviar, or live fish for the aquarium trade, but are in favor of allowing private aquaculture operations to rear lake sturgeon through the Wisconsin Lake Sturgeon Aquaculture Agreement (WLSAA).

As part of Wisconsin's Lake Sturgeon Management Plan, the WLSAA would establish a committee, including private aquaculture, to review the criteria used for stocking, transfers, and genetics, and would allow private commercial operations to rear lake sturgeon for research and rehabilitation, but not for caviar, flesh or aquarium sales. By not allowing commercialization of lake sturgeon, the largest and healthiest population of lake sturgeon in North America should be protected from potential pirating of fish for sale on the "black market" or genetic pollution by imported lake sturgeon for commercial purposes. When first proposed, legalizing lake sturgeon commercialization for private aquaculture attracted public opposition, and will almost certainly again. Sturgeon for Tomorrow and the Wisconsin Wildlife Federation also support WLSAA proposal.

The Department of Agriculture, Trade and Consumer Protection (DATCP) advocates a proposal allowing implementation of the recommendations by SMAT while providing the opportunity for a limited number of private commercial operations to participate in a pilot project which would allow for lake sturgeon to be raised for commercial purposes with oversight from DATCP, DNR and SMAT. A pilot project assessing lake sturgeon market potential while assisting with research and rehabilitation of the species would require many years to complete, but could thoroughly assess the value to Wisconsin's aquaculture industry and the true impact of lake sturgeon aquaculture on wildstocks.

The Regulatory Options for the Commercial Rearing of Lake Sturgeon is a compilation of information on lake sturgeon biology, current regulations and enforcement, aquaculture potential, disease and health related issues, and public sentiment, plus positive and negative characteristic for each option. Contacts are listed in the rear of the report if questions or concerns arise.

In Wisconsin, the lake sturgeon is an important cultural and recreational fish that was once used for economic gain. Native American peoples throughout the Great Lakes and upper Mississippi River basins revered the fish as an important food source as well as a spiritual icon. European settlers used the fish for its flesh, caviar and swim bladders, which produced "isinglass," an important early additive for a variety of products including wine and paint. Lake sturgeon stocks were nearly wiped out throughout their range due to overharvest, commercial fishing, the building of dams on spawning streams and pollution.

Wisconsin began pro-active management of its lake sturgeon populations in 1903 with the passage of the first lake sturgeon harvest regulations, which prohibited the harvest of a fish less than 8 pounds. Since 1903, dozens of regulations, including the prohibition on commercial rearing of lake sturgeon, the ban on the sale of live sturgeon and the barring of lake sturgeon flesh or caviar sales, have been enacted to manage the harvest and protect wild lake sturgeon stocks. Wisconsin is currently home to the largest and healthiest lake sturgeon population remaining in North America. Recreational interests in Wisconsin include a hook and line fishing season as well as a spearing season. Wisconsin's lake sturgeon management program is considered a world model for its management techniques and progressive protection of wild lake sturgeon stocks.

In the mid-1990's, private aquaculture in Wisconsin expressed an interest in re-establishing the commercialization of lake sturgeon to meet a growing demand for the caviar and meat produced by the fish. The demand for sturgeon, especially in Eastern Europe, has decimated wild sturgeon stocks to the point of extinction throughout much of the world. The Wisconsin Legislature considered removing the rearing prohibition on lake sturgeon in 1997 as part of the biennial budget bill. In response, recreational lake sturgeon fishers and spearers voiced opposition to the proposal and subsequently the Legislature amended the language to the following:

95.60(6)(c) of the Wisconsin State Statutes

> (c) the Department of Agriculture, Trade and Consumer Protection, in consultation with the Department of Natural Resources, shall study regulatory options that would enable commercial rearing of lake sturgeon while protecting the wild lake sturgeon population. The Department of Agriculture, Trade and Consumer Protection shall submit the results to the Legislature under s. 13.172 (2) no later than December 31, 2000.

Pursuant to this statute, the Wisconsin Department of Agriculture, Trade and Consumer Protection and the Wisconsin Department of Natural Resources conducted a review of the scientific literature, contacted experts on sturgeon biology and consulted with aquaculture authorities to compile a broad base of knowledge on lake sturgeon. The Departments invited the public to participate in the information gathering process and solicited comments on the draft report of Regulatory Options for the Commercial Rearing of Lake Sturgeon. Interests considered during the process were private commercial operations (aquaculture industry), sturgeon recreational interests, the US Fish and Wildlife Service (USFWS), Tribal interests, DNR sturgeon management program, DNR law enforcement experts, University of Wisconsin—System sturgeon research Introduction experts, health and disease experts, and marketing consultants.

DATCP gathered input at a public workshop in January of 2000 to review and discuss issues and concerns related to the commercialization of lake sturgeon in Wisconsin. Over 30 participants, representing various issues and viewpoints relating to the commercial rearing of lake sturgeon in Wisconsin, attended the meeting. The open discussion engaged many issues related to the public and private rearing of lake sturgeon, including genetics, disease, economics, and regulation. All meeting participants and any other interested parties received the report's participant comments, outline, timeframe and draft.

From the public involvement process, five options have emerged that merit consideration by the State Legislature:

Status quo – continue the prohibition on the sale of live lake sturgeon and lake sturgeon flesh and caviar.

Implement the Wisconsin Lake Sturgeon Aquaculture Agreement, which would establish standard technical criteria for public and private lake sturgeon rearing operations for rehabilitation and stocking purposes only (recommended by the Sturgeon Management Assessment Team in the Wisconsin Lake Sturgeon Management Plan).

Create a statutorily defined Lake Sturgeon Commercial Management Board to develop the conditions of operation and oversee all commercial lake sturgeon operations in Wisconsin (conceived and recommended by the aquaculture industry).

Develop a pilot program, the Wisconsin Lake Sturgeon Commercialization Pilot Project, to work in conjunction with the directives and goals of the Wisconsin Lake Sturgeon Management Plan, but allow a limited number of private commercial operations to research and explore the potential commercial markets available from rearing lake sturgeon while assisting with the propagation of the species for rehabilitation and stocking purposes (conceived and recommended by DATCP).

Full legalization of the harvest purchase, sale, trade, barter, possession, control and transportation of lake sturgeon by private commercial aquaculture operations in Wisconsin.

The following sections provide a summary of background information on lake sturgeon biology, current regulations and enforcement, aquaculture potential, disease and health related issues, and public sentiment, plus the pros and cons for each listed option.

The value of lake sturgeon in Wisconsin is linked to recreational fishing and spearing, traditional Tribal use, and as an aesthetic resource, which is viewable in its natural habitat during the spring spawning period. The potential value from the commercial rearing of lake sturgeon has yet to be determined, but Wisconsin currently has an established and successful aquaculture industry to use as a model and resource when necessary.

Wisconsin has the most significant remaining lake sturgeon population in North America, and numerous viable fisheries continue to exist through rigidly regulated harvest management regulations and programs. A fall hook and line fishery produces an average annual harvest of 300 fish statewide, while a winter spear fishery on Lake Winnebago produces an average annual harvest of 1400 sturgeon. Thousands of individuals from Wisconsin and over 35 other states participate each year in one or both of the current fisheries.

Tribal interest and use of lake sturgeon in Wisconsin is increasing through efforts such as the Menominee Reservation Lake Sturgeon Recovery Plan. This plan, developed and implemented jointly by the Tribe, DNR, the USFWS and the general public, has begun the long term process of restoring lake sturgeon to Reservation waters for the ultimate benefit of all Tribal members.

Individuals from numerous states also participate annually in the sturgeon watch that occurs during the spring spawning period. Thousands of people travel to rivers such as the Wolf in east central Wisconsin each year in late April to see the spawning ritual of the giant fish as they concentrate along the riverbanks and in rapids to lay their eggs.

While the sale of lake sturgeon is currently prohibited, the fish does hold unexplored potential for aquaculture interests in Wisconsin. Lake sturgeon sales were permitted until the beginning of the 20th Century, but laws were enacted to protect the resource from potential extinction in Wisconsin waters. Therefore, Wisconsin's private aquaculture industry is interested in rearing lake sturgeon to supplement the demand being created around the world.

Sturgeon populations in other parts of the world are in decline from overharvest and poaching for their valuable caviar. Wisconsin lake sturgeon conservation interests believe creating a lake sturgeon aquaculture industry in Wisconsin would result in the same declining lake sturgeon populations as those experienced in other parts of the world. The aquaculture industry feels developments with technology and management practices, and the use of lake sturgeon tagging, will prevent such a situation in Wisconsin.

6 Regulatory Options for Commercialization

Under 95.60 of the Wisconsin State Statutes, the Wisconsin Department of Agriculture, Trade and Consumer Protection was assigned the task of researching, organizing and distributing the State Legislature's report on Regulatory Options for the Commercial Rearing of Lake Sturgeon. DATCP, in cooperation with DNR, consulted other interested parties on various issues to provide a comprehensive publication evaluating the necessary aspects of viability for commercial rearing of lake sturgeon by private commercial operations in Wisconsin. Numerous sources submitted information and opinions to DATCP for consideration in the report. Once the gathering of data was complete and the report was sufficiently organized, DATCP released the draft to the public for comment. The following five options were developed from the input gathered through the public involvement process:

Continue the status quo

The Wisconsin State Legislature could decide not to change the current regulations and leave the current laws in place. Current law states: 95.60(6)(a) of the Wisconsin State Statutes — No person, except the Department of Natural Resources, may rear lake sturgeon in a fish farm.

Pros

Continues DNR's successful management practices and protection of wild lake sturgeon resources;

Affords full protection of wild lake sturgeon stocks;

Provides continued and effective enforcement;

Continues rehabilitation of wild sturgeon populations under DNR's current management program.

Cons

Limits DNR's ability to contract with private aquaculture to supplement lake sturgeon rehabilitation efforts;

Prohibits exploration of potential markets by private aquaculture;

Prohibits involvement by private aquaculture in the propagation of the lake sturgeon species;

Limits involvement from private aquaculture experts;

Fails to consider advancements in technology and aquaculture management practices.

WI Lake Sturgeon Aquaculture Agreement (WLSAA)

Developed by the Sturgeon Management Assessment Team, the Wisconsin Lake Sturgeon Aquaculture Agreement would establish a cooperative partnership agreement between the Department of Natural Resources, the United States Fish and Wildlife Service (USFWS), the Department of Agriculture, Trade and Consumer Protection, other governmental agencies, academia, Native American tribes, special interest groups and the private commercial aquaculture industry. The agreement would establish a technical committee to review the criteria used for stocking, transfers, and genetics. In addition, all stocking and reintroduction proposals would be reviewed by the SMAT. The Agreement would allow lake sturgeon species propagation by private commercial operations for research and rehabilitation purposes, but not for caviar, flesh or aquarium sales.

Pros

Promotes a cooperative effort with private aquaculture in the propagation of lake sturgeon in Wisconsin;

Develops a comprehensive, statewide lake sturgeon management plan;

Provides clear goals and objectives outlined in Wisconsin's Lake Sturgeon Management Plan and incorporates a role for private aquaculture.

Cons

Limits role of private aquaculture to contract work for lake sturgeon rehabilitation and stocking purposes;

May require increased enforcement efforts;

May not provide adequate protection of wild lake sturgeon populations;

Fails to guarantee private aquaculture will be allowed to rear lake sturgeon.

Lake Sturgeon Commercial Management Board

The Wisconsin Aquaculture Association is recommending the organization and establishment of a Lake Sturgeon Commercial Management Board, which, by statutory authority, will determine the conditions of operation for public and private commercial lake sturgeon operations in Wisconsin, including public hatcheries. Membership of the Board would consist of representatives from various interest groups and government agencies. The Board would also be permanent and have authority determined by the State Legislature. Finally, the Lake Sturgeon Commercial Management Board would convene on a regular basis to evaluate and manage issues related to lake sturgeon.

Pros

Promotes a cooperative effort to address the common issue of lake sturgeon propagation in Wisconsin;

Provides an alternative approach to current lake sturgeon program management;

Includes extensive involvement by private aquaculture.

Cons

May not provide adequate protection of wild lake sturgeon populations;

Needs to define goals on lake sturgeon management;

Potentially creates the need for more staff and regulation;

Possible opposition to composition and mandate of the Board by the public;

Establishes a new government entity.

The WI Lake Sturgeon Commercialization Pilot Project

Conceived through DATCP as an effective alternative between the Wisconsin Lake Sturgeon Management Plan and the Lake Sturgeon Commercial Management Board, the Wisconsin Lake Sturgeon Commercialization Pilot Project would utilize the goals, objectives and management recommendations of the Wisconsin Lake Sturgeon Management Plan, but would complement WLSAA by allowing private aquaculture the opportunity to explore and evaluate the marketing potential of lake sturgeon while assisting with research and rehabilitation. The Pilot Project would allow a specified number of private commercial operations in Wisconsin to participate with the Sturgeon Management Assessment Team in the implementation of identified actions from the Wisconsin Lake Sturgeon Management Plan. All participants in the Pilot Project would be subject to protocol designed to ensure the safeguard of lake sturgeon health and to protect native lake sturgeon populations. Private commercial operations would assist with the statewide propagation of lake sturgeon through research and rehabilitation of the species. Under the Project, SMAT would use the private commercial operator in the same manner public and tribal hatcheries are used, except a predetermined number of lake sturgeon may be sold at the operator's discretion. SMAT and the participating private commercial operations would be required to regularly report progress with the project.

Pros

Promotes a cooperative effort to address significant issue of lake sturgeon propagation in Wisconsin;

Provides an opportunity for a limited number of private commercial operators to evaluate the marketing potential of lake sturgeon;

Maintains the integrity of the SMAT proposal and private aquaculture is involved in the rearing of the species;

Offers an opportunity to explore lake sturgeon marketing potential while minimizing the impact on wild stocks.

Provides market-based incentives for private aquaculture to invest sufficient resources for rearing while still operating under extensive oversight and control.

Cons

Raising lake sturgeon for the sale of flesh and caviar is a long term goal which may require 20 years;

May not provide adequate protection of wild lake sturgeon populations;

May increase the risk of illegal sale or laundering of wild sturgeon stocks through open markets for caviar, flesh and live fish.

Would require increased enforcement efforts.

Full Legalization of Commercial Activities

Previously considered by the State Legislature, the repeal of 95.60 (6)(a) of the Wisconsin Statutes would permit private aquaculture in Wisconsin the opportunity to rear lake sturgeon for sale with minimal government interference. Such a change would allow legal harvest, purchase, sale, barter, trade, possession, control and transportation of lake sturgeon by any farm registered with DATCP.

Pros

Lake sturgeon propagation for commercial purposes would be available to private aquaculture;

DATCP and DNR regulatory authority remains status quo.

Cons

Wild lake sturgeon populations may be severely impacted by laundering, illegal stocking, aquarium releases, genetic mixing, and fish health issues;

Enforcement to protect against illegal harvest would need to increase with associated increased costs and effort;

Considerable opposition from public and private interests.

Historical Background

Sturgeon stocks have experienced a worldwide decline not only because of the impact of human activities on sturgeon habitat, but because of the high value of the fish flesh and caviar produced from their eggs. Commercial and sport fishing pressure combined with environmental pressure from dam construction and the development of adjacent watersheds are major factors contributing to stock decline.

Historically, sturgeon products have been considered valuable in Europe, Asia, and North America. Before 1900, the United States sturgeon landings were estimated to be 15 million pounds on the East Coast and 10 million pounds on the West Coast. Out of concern for wild sturgeon stocks, most U.S. commercial sturgeon fisheries were closed by the mid 1990's. Today, the U.S. commercial sturgeon fishery is small and consists primarily of white and Atlantic sturgeon.

The international demand for sturgeon, both for its flesh and for its caviar, has always placed pressure on the world's sturgeon fisheries. The decline in sturgeon stocks was recognized in Russia and the United States in the second half of the 1800's, and the first recorded attempts at artificial propagation of sturgeon were by Ovsyanikov in Russia (1870) and by Green in the United States (1875). Programs to artificially propagate sturgeon were established in North America, and significant efforts were made between 1875 and 1912 to develop hatchery technology for Atlantic and lake sturgeon. A few efforts were made after 1912, but by 1920 serious interest in artificial propagation of lake sturgeon in North America was abandoned.

Sturgeon hatchery research continued in the Soviet Union, however, and was accelerated during the 1950's as part of mitigation programs to compensate for habitat alterations. Technical obstacles to artificial propagation were overcome. (Excerpt from the Hatchery manual for White Sturgeon with application to other North American Acipenseridae by Fred Conte, Serge Doroshov, and Paul Lutes. 1988. University of California, Division of Agriculture and Natural Resources). In the United States today, sturgeon ranching or farming occurs primarily in California and Idaho where the fast growing white sturgeon from the Pacific Ocean are used.

Lake Sturgeon Aquaculture in Wisconsin—1975 to the Present

Efforts to propagate lake sturgeon in Wisconsin were initiated in the late 1970's by Binkowski and Czeskleba (Binkowski and Czeskleba 1980, Czeskleba et. al. 1985), partially supported by funds from Sturgeon for Tomorrow. Sturgeon for Tomorrow, a private conservation group from the Lake Winnebago region, was founded in 1977 to promote wise use of Wisconsin's lake sturgeon resources and support research to develop techniques for artificial propagation of sturgeon for research and conservation purposes. By the early 1980's, some of the obstacles limiting artificial propagation of lake sturgeon had been eliminated or minimized, so the Wisconsin DNR established a program to rear lake sturgeon at its Wild Rose Hatchery for use in rehabilitation efforts in Wisconsin waters. From 1980 to the present, Wisconsin lake sturgeon eggs, sac fry or fingerlings have been used to rehabilitate wild stocks or have been used for research in numerous states and provinces including Wisconsin, Michigan, Minnesota, Ohio, Missouri, Tennessee, Georgia, Manitoba and Ontario. Since 1979, the Fisheries Research Unit at the University of Wisconsin-Milwaukee Great Lakes WATER Institute has conducted numerous experiments on the biology of lake sturgeon including

culture techniques [Binkowski 1997; Czeskleba et al (1985); Binkowski and Czeskleba (1980)].

The extensive work conducted over the past 20 years by Wisconsin DNR and University of Wisconsin-Milwaukee Great Lakes WATER Institute has shown lake sturgeon to be successfully reared in a hatchery system. However, this technology is very complex and costly (Binkowski 2000, 1997). Lake sturgeon remain a difficult species to culture. Existing research shows that lake sturgeon is a species that would be difficult to profitably produce under commercial aquaculture conditions.

Specific data suggests:
Lake sturgeon adults in spawning condition are difficult to locate and gametes are difficult to collect without negatively impacting the fish (Binkowski 1997, Binkowski and Czeskleba 1980). Lake sturgeon eggs are generally very difficult to collect due to the limited number of spawning females in a population, and due to their unique reproductive biology which, unlike most other fish species in Wisconsin, causes ovulating females to give up their eggs very sparingly (Doroshov and Binkowski 1984).

The incubation and successful hatching of sturgeon eggs can be a sensitive and difficult operation requiring specific temperature control and treatment for disease, especially fungal disease (Binkowski 2000, Binkowski 1997, Czeskleba et al 1985, Wang et al 1985). There are few chemicals approved by the FDA that can be used to treat fungal infections of sturgeon eggs.

Rearing lake sturgeon in a hatchery is very expensive as the fish do not take well to commercial fish food diets during the early life stages and must be fed expensive live or natural foods (Czeskleba et al 1985, Binkowski and Doroshov 1984). Providing the necessary food for first feeding larvae is very labor intensive and costly.

Lake sturgeon are very difficult to culture. They require optimal environmental conditions for successful growth and survival, and the technology is very complex and costly (Binkowski 1997). The cost analysis for the culture of lake sturgeon was reported on by Binkowski 1997, which included a detailed analysis of labor, equipment, supplies, and utilities. The final cost per fish at six months post hatch was $5.56. This cost was determined based on the needs for lake sturgeon resources for experimental purposes. All biological, physical, and chemical parameters were required to assure the highest quality product. We believe this same approach would be required for commercial production. If a less complete approach were used, the quality of product would be severely compromised. Our cost estimate of $5.56 is similar to the cost incurred by a private operation in Wisconsin (Red Cliff Tribal Hatchery), where their cost was estimated to be $5 to $6. Lake sturgeon culture is very labor intensive, the Red Cliff reported that 25% of the tribal hatchery labor hours per day were spent working on lake sturgeon.

A cost analysis was also conducted for one and two-year-old lake sturgeon cultured at the Great Lakes WATER Institute. The final cost per fish at one year post-hatch was $27.62 and for two years post-hatch was $234.06. Consequently, based on 20 years of lake sturgeon research experience that includes a significant effort on culture techniques, which would suggest that commercialization of lake sturgeon would not be cost-effective and competitive with other cultured species in Wisconsin.

Optimal conditions in the hatchery system must be maintained – water quality, proper feeding regime, measures to eliminate gas supersaturation – which are very labor intensive and costly even in research hatchery or rearing facilities (Binkowski 1997, Binkowski and Meyers 1983).

Contrary to popular belief, lake sturgeon do not feed on detritus and fish excrement on the bottom of ponds and fish hatchery raceways and will not "keep a hatchery clean" (Binkowski 2000)

Lake sturgeon grow very slowly and would likely not reach a marketable size (8-10 pounds) for 5 to 6 years in a hatchery system (Binkowski 1997).

Compared to other popular Wisconsin gamefish such as walleye or perch, lake sturgeon have a flesh that is relatively high in fat with a somewhat fishier taste, therefore producing a flesh with a limited market potential.

The slow growth of lake sturgeon would prevent them from reaching a size needed for caviar production until they have been in a hatchery system for potentially 20 years (Binkowski 1997, Doroshov and Binkowski 1984).

Lake sturgeon could be raised to a size suitable for private aquaria in one year, but may pose a threat to Wisconsin's natural sturgeon populations because of unwanted release and the potential introduction of disease into the wild stock (Gessner 2000).

Disease and Health Related Issues

Little is known about diseases in lake sturgeon despite existing in this region for many years. Very little scientific data has been published regarding disease and health related issues in lake sturgeon. Unfortunately, the lack of data is not limited to the lake sturgeon, many other sturgeon species have only limited information available on disease and health issues.

The unique biological characteristics of the lake sturgeon must be considered when developing a lake sturgeon health program. First, lake sturgeon travel extensive distances making it difficult for infectious organisms to be limited to a discrete body of water. An infected lake sturgeon can travel many miles to waters where it may have never experienced a particular infectious organism. In addition, many disease organisms in fish are harbored in apparently normal fish for the duration of their life span and lake sturgeon live for many years. If disease carrying lake sturgeon do not succumb to the disease, they are capable of passing the disease organism to other sturgeon or native fish. An infected fish may or may not succumb to disease, or may become a carrier.

The white sturgeon is perhaps the most extensively studied species from a disease perspective. The White Sturgeon Iridovirus (WSIV) is common and has been the most studied disease within the North American sturgeon species. Disease transmission occurs from the female to her eggs. Illness and death occur in white sturgeon that are less than 12 months old, while adults remain unaffected. It has been studied almost exclusively in Idaho, California and Oregon and is regarded as a manageable stress-mediated disease. Little is known about the geographic distribution of WSIV beyond the states of Idaho, California and Oregon but recent

evidence suggests the disease is present in many regions of white sturgeon habitation.

Some private commercial operations around the country, including Wisconsin, have developed and continue to use programs ensuring higher fish health standards than currently employed by public hatcheries or public waters (Kebus, 1996). An example employing white sturgeon exists at Clear Springs Foods in Idaho (see Appendix II). Such operations have offered their expertise and fish health personnel to public sector hatcheries, resulting in benefits for both the public and private interests.

The opportunity to transfer disease organisms is conceivable within the State's current lake sturgeon management structure. Lake sturgeon have been and will continue to be exchanged throughout Wisconsin, the Midwest and North America by governmental and resource agencies. While an existing program requiring the monitoring of WSIV is currently in place, any further investment in lake sturgeon by the State should include the further development and expansion of a disease and health management program to include other diseases.

Lake Sturgeon Health Management

The Department of Agriculture, Trade and Consumer Protection's Division of Animal Health–Aquaculture Program presently regulates the importation of live fish and fish eggs, private commercial operation registration, and all health requirements for fish stocked in Wisconsin's public waters. This responsibility includes health requirements for the importation and stocking of lake sturgeon in public waters. The Division employs a qualified aquaculture veterinarian, who is available to public and private operations, to perform the Department's fish health obligation.

A health certificate indicating the fish is free of visible signs of infectious and contagious disease, specifically WSIV must accompany all sturgeon imported into Wisconsin. Additional DATCP regulations require that any person who diagnoses or finds evidence of WSIV must promptly report this to the Division of Animal Health.

DATCP

The role of the Wisconsin Department of Agriculture, Trade and Consumer Protection concerning sturgeon is outlined primarily in State Statute Chapters 95.60 and 29.736. DATCP is responsible for monitoring fish health in aquaculture operations, including state hatcheries.

DATCP supports option #4, the Wisconsin Lake Sturgeon Commercialization Pilot Project. Although lake sturgeon are a valued natural resource to Wisconsin and should be protected from undue harm, the Department advocates a long-term examination of potential lake sturgeon markets and the positive and negative effects private lake sturgeon aquaculture would have on wild stocks, including stocking and rehabilitation of the species.

DATCP Division of Animal Health

The Division of Animal Health has developed in-depth health policies for other animal industries, including species of fish, which address varied diseases or criteria for specific situations. An example would be the fish health advisories for Heterosporsis in Yellow Perch and Walleye or the rules for Whirling Disease in trout and salmon. To accomplish such a feat, the Division successfully worked with angling groups, lake owners, private commercial operations, tribal interests, the Department of Natural Resources and others to secure the necessary input to make an informed decision regarding the best possible solution to the situation.

The Division of Animal Health is investigating several suitable models it could use to develop, with other lake sturgeon shareholders, an effective and efficient lake sturgeon health program.

All private commercial fish operations are currently required to register with DATCP's Division of Animal Health. Registration requires private commercial operations to maintain records on fish health and importation and exportation, including records of fish moved on and off each operation.

Division of Animal Health employees currently have the authority to review the records of any private commercial operation without notice. Failure to maintain proper records can result in loss of operation registration.

With proper resources, the Division could research, design, implement and promote a statewide lake sturgeon health plan. Such a plan may require the monitoring of lake sturgeon activities and better-trained veterinarians to oversee lake sturgeon health.

The Division of Animal Health presently is the primary fish health customer for the Wisconsin Veterinary Diagnostic Laboratory (WVDL) at University of Wisconsin–Madison. Collaborative efforts on lake sturgeon health between the Division and WVDL could further increase testing capabilities for WSI, along with testing for other organisms of concern to lake sturgeon. Upon completion of the new WVDL, the facilities and staff will be among the best in the country. In addition, the University of Wisconsin—Madison School of Veterinary Medicine is providing expertise in special veterinary health techniques (such as ultrasound on lake sturgeon) and could play a vital role in Wisconsin's lake sturgeon health program efforts.

Lake sturgeon reared on private commercial operations could be identified and traced for origin if a situation would arise requiring tracking methods through the Division of Animal Health.

With improved regulatory oversight, the legal ramifications of non-compliance with registration requirements would discourage illegal "laundering" of lake sturgeon on Wisconsin's private commercial operations.

Fish identification through tagging on commercial operations has been developed and successfully implemented in other states.

DNR

The role of the Wisconsin Department of Natural Resources concerning sturgeon is outlined primarily in State Statute Chapter 29. DNR is responsible for the protection, management and well being of fish stocks, including sturgeon, in the wild.

The Department of Natural Resources supports Option #2, participation of private commercial aquaculture operations in the rearing of lake sturgeon under a WLSAA for rehabilitation purposes, but also supports remaining with the status quo. The Department strongly opposes relaxing the prohibition of commercial rearing of lake sturgeon for flesh and/or caviar, or the sale of live fish to the aquarium industry.

DNR Bureau of Fisheries Management and Habitat Protection

An immediate concern regarding protection and enhancement of the lake sturgeon population in North America is the large number of states and provinces that still allow the commercialization of lake sturgeon flesh, caviar and live fish. If the Convention on the International Trade of Threatened and Endangered Species (CITES) is effective in controlling, or at least reducing, the illegal trade of European and Asian sturgeon products, then illegally caught or produced lake sturgeon from North America would be a viable avenue for the continued success of foreign lake sturgeon markets. The incentive is high for illegal acts, especially in the caviar and aquarium markets.

Illegal harvest of lake sturgeon could easily decimate targeted stocks. In addition, the unwanted release from a private commercial operation or an aquarium industry could seriously hamper recovery efforts due to the potential introduction of disease and possible dilution of the natural gene pool.

Aquaculture will obviously play an important role in North American lake sturgeon recovery efforts, and private commercial operations should be a partner in these efforts. Both public and private interests involved in this issue need to thoroughly discuss and agree upon the aquaculture standards that must to be met to ensure the overall success of efforts targeting the management or recovery of the public sturgeon resource. These standards have been developed by representatives of DNR, the U.S. Fish and Wildlife Service (USFWS), the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), the Menominee Tribe, the University of Wisconsin—System, the aquaculture industry, several private sporting organizations, the

sport fishing industry, and the angling public, and are summarized as a recommendation in the recently completed Wisconsin Lake Sturgeon Management Plan (see appendix I).

DNR Bureau of Law Enforcement

Due to the precarious status of wild sturgeon populations and a high black market value, enforcement of lake sturgeon regulations has been a continuing high priority for Wisconsin Conservation Wardens since the mid-1900s. In addition, the DNR enlists the assistance of many volunteers each spring as "sturgeon guards" to provide 24-hour watch over major spawning sites along the Wolf River to protect the fish from poachers.

No commercial harvest of lake sturgeon is allowed in Wisconsin. Furthermore, to prevent illegal "laundering" of lake sturgeon into commercial markets, the legislature found it necessary to enact sec. 29.503(3), Wis. Stats., which prohibits Wisconsin licensed wholesale fish dealers from buying, selling, bartering, trading, possessing, controlling or transporting lake sturgeon regardless of the source.

In order to protect Wisconsin's native lake sturgeon populations, the Legislature has enacted regulations prohibiting all commercialization of lake sturgeon. Historically, lake sturgeon have had a great "black market" value with the flesh and roe being highly prized. Consequently, Conservation Wardens have found it necessary to devote extraordinary amounts of time and resources to protect this valuable native species, including overt and covert investigations into the illegal harvest and marketing of the fish. In addition, CITIES restrictions along with collapsing sturgeon populations due to over harvest in Eastern Europe, have reportedly increased worldwide interest in North American sturgeon as a possible source of roe for high-value caviar.

Because of the extremely high value and potential profits associated with a lake sturgeon trade, conservation wardens are concerned about the potential for any unscrupulous private commercial operations illegally "laundering" lake sturgeon taken from the wild. Once an illegal lake sturgeon is in an authorized private commercial operation, it would be difficult to prove where the fish originated. Identification of individual lake sturgeon using fin clips is impossible and using fin clips for batch identification of sturgeon is not effective due to fin regeneration. Larger sturgeon (fish larger than 10" or 1.5 to 2 years old) can be individually identified most effectively using PIT (passive induced transponder) tags, but exhibit only a 70% success rate (Thuemler and Fajfer 1999). The issue of "laundering" lake sturgeon is further complicated by the fact that all farm-raised fish are currently exempt from wholesale fish dealer requirements (note: wholesale fish dealer restriction mentioned above). Allowing commercial rearing of lake sturgeon would open the door for the movement of wild sturgeon flesh and caviar into commercial markets by third party operations under the guise of being farm raised fish. This would have a negative impact on Wisconsin's lake sturgeon populations and unjustly call into question the operations of honest private fish farms. Finally, legalization of commercial rearing of lake sturgeon would dramatically increase warden workloads with the need for a significant increase in patrol and enforcement activities on waters supporting native lake sturgeon populations.

The commercial rearing of lake sturgeon by private aquaculture would not only open the doors for movement of wild sturgeon into commercial commerce but would also threaten one of the most viable remaining lake sturgeon populations in North America and the world.

Lake Sturgeon Biology Facts & Figures

Description:

Body heavy, torpedo-shaped, angular (5-sided) in young, but round in adults; total length of adults averages 45"; snout short, conical; barbels on lower snout (4), smooth; upper lobe of tail fin pointed without threadlike (filamentous) extension (compare with shovelnose sturgeon); young—gray or brown dorsally with dusky dorsal and lateral blotches; adults gray to olivaceous dorsally and white ventrally.

Biology:

Lake sturgeon are slow growing, long-lived and late sexually maturing creatures. Females do not mature to spawn for the first time until they are 20 to 25 years old when raised in the wild (55" to 60" in total length) and then spawn only once every four years while potentially living up to 100 years. Males mature first at age 12 to 15 (40"to 45"), spawn every other year and live up to about age 40. After about a length of 40", females grow slightly faster than males and will generally grow to a much larger size due to their greater potential age longevity. Generally, in the wild, lake sturgeon will attain a total body weight of 10 to 15 pounds in the first ten years of their life, and females will become a caviar fish for the first time at about age 20 to 25. Lake sturgeon in Wisconsin spawn in late April to May in rapids and along current swept rocky areas in rivers they inhabit or rivers flowing into lakes they inhabit, when water temperatures reach 50° to 56° Fahrenheit. Lake sturgeon will migrate well over 100 miles against a river's current to find optimal spawning areas (Bruch 1999).

Distribution and Populations Status:

Lake sturgeon, Acipenser fulvescens, inhabit large river systems primarily in the Mississippi River, Hudson Bay and Great Lakes basins. By the early 1900's, many populations of lake sturgeon throughout their range had been greatly reduced or close to extinct because of overfishing, habitat loss, the construction of dams, and pollution (Harkness and Dymond 1961). Wisconsin has the longest running active management program for any sturgeon species in the world, since 1903. Continuous management has left the state with the best and most viable populations of lake sturgeon in the fish's natural range. Lake sturgeon have few to no natural predators after attaining a size of 12" to 15", but are very susceptible to overharvest as premature adults and adults. Lake sturgeon can tolerate only an annual harvest rate of 5%, compared to an acceptable annual harvest rate of 25% to 35% for other gamefish species, such as walleye or bass.

Lake Sturgeon in Wisconsin

In Wisconsin, lake sturgeon are present in the Mississippi River, Lake Michigan, and Lake Superior drainage basins.

The Mississippi River Basin:

Rivers include the Mississippi, St. Croix, Chippewa, Flambeau (and major tributaries), and Wisconsin. In the Wisconsin River, records place lake sturgeon upstream to the Castle Rock Flowage (Adams County).

Lake Superior Basin:

Lake sturgeon are found in the comparatively shallow waters from Superior to Bark Point, in the vicinity of the Apostle Islands, and in the Bad River (Ashland County). Lake sturgeon are common in the St. Louis River.

Lake Michigan Basin:

Lake sturgeon are present in Green Bay, Lake Michigan, the Menominee River upstream to the White Rapids Dam, the Fox River upstream to Lake Puckaway, and the Wolf River upstream to Shawano. The Wolf River system includes Lakes Winnebago, Butte des Morts, and Winneconne, plus the Embarrass River.

Other:

Lake sturgeon have been introduced to lakes where natural reproduction did not occur, including: Big Cedar Lake (Washington County), the Madison lakes (Dane County), Chain of Lakes (Waupaca County), and Pear Lake (Washburn County).

In Wisconsin, lake sturgeon are common in the Menominee River, the lower Wolf and upper Fox Rivers, Lakes Poygan, Winneconne, Butte des Mort and Winnebago, Lake Wisconsin, the St. Croix River to Gordon Dam, Namekagon River below Trego Dam, and the Chippewa and Flambeau rivers. Lake sturgeon are uncommon to rare in the lower Wisconsin River, Mississippi River, the Madison lakes, and Lakes Michigan and Superior.

Lake Sturgeon Regulation in Wisconsin

Wisconsin law currently bans commercial harvest of lake sturgeon in Wisconsin. State law also prohibits licensed wholesale fish dealers from buying, selling, bartering, trading, possessing, controlling or transporting lake sturgeon regardless of the source. State Statutes also prohibit the importation or sale of lake sturgeon legally harvested by commercial fishers in other jurisdictions, such as from Canada.

Sport fishing regulations are also very restrictive towards anglers. Upon removal of a lake sturgeon from state waters, the angler is required to immediately tag each sturgeon and register with the DNR before 6:00pm on the day the fish is taken. Specific rules vary among bodies of water, with most locations having a fall hook and line season of six to eight weeks with a season bag limit of only one sturgeon and minimum size limit of 50 to 70 inches. The Lake Winnebago – Wolf River system is unique with sport harvest limited to a three-week spearing season through the ice during February. However to ensure against over exploitation, the season is closed within 24 hours of 80% of the harvest objective for any one of the three sex and maturity specific harvest caps is reached. The Lake Winnebago bag limit for spearing is one fish per season with a 36" minimum size limit.

Lake Sturgeon Management and Trade in North America

Since the early 1980's, there has been a steady increase in the number of states and provinces with an interest in active lake sturgeon management, restoration and research (K. Graham, MO DOC and D. Folz, WI DNR, personal communications). Lake sturgeon have been recognized by CITES as a species in potential danger and in need of improved conservation practices. Although the trade may benefit commercial interests in terms of caviar, flesh or live fish, there is also the potential to negatively impact existing lake sturgeon populations or hamper recovery efforts.

In 1998, Ron Bruch of the Wisconsin Department of Natural Resources summarized the status of legal trade and management of lake sturgeon in North America. Fisheries biologists in 15 states and provinces within the native range of lake sturgeon that either still have lake sturgeon present in their waters or have developed recovery plans, were polled and asked the following questions:

Does their state or province have an active lake sturgeon population and/or harvest management program?

Can wild lake sturgeon flesh, caviar or any other body parts be legally sold in their state or province?

Can lake sturgeon be legally raised and sold as live fish (ornamental or otherwise) or as fish products through private aquaculture in their state or province?

States and provinces polled include Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Tennessee, Wisconsin, Alberta, Manitoba, Ontario, Quebec, and Saskatchewan.

Of the 15 states polled on the status of their lake sturgeon management and trade activities, 12 of the 15 have a lake sturgeon management and/or a recovery plan either for the entire state or province or for their waters of highest interest or need. While many viable sport, as well as some commercial fisheries for lake sturgeon are in operation at this time (Todd 1998, Mosher 1998), all states and provinces polled impose some level of harvest restriction through regulations. Lake sturgeon flesh, caviar or other body parts can be legally sold in 9 of the 15 states and provinces polled. Live lake sturgeon, as ornamental fish in the aquarium, can be legally sold in 7 of the 15 states or provinces, and not sold in this manner in 7 of 15, while the one remaining jurisdiction was not certain whether this trade was legal or not. The following table lists the polling results from each state and province.

Management and Authorized Trade of Lake Sturgeon in North America

State or Province	Has Lake Sturgeon Management Plan	Has Legal Trade of Flesh and Caviar	Has Legal Trade of Live Lake Sturgeon
Illinois	No	No	No
Indiana	No	No	No
Iowa	No	No	No
Michigan	Yes	Yes	Yes
Minnesota	Yes	Yes	Yes
Missouri	Yes	No	No
New York	Yes	Yes	Yes
Ohio	Yes	Yes	No
Tennessee	Yes	No	No
Wisconsin	Yes	No	No
Alberta	Yes	Yes	Yes
Manitoba	Yes	Yes	Yes
Ontario	Yes (L. Huron)	Yes	?
Quebec	Yes	Yes	Yes
Saskatchewan	Yes	Yes	Yes

Management of lake sturgeon has become a prominent part of the resource management programs of most states and provinces within the native range of the species. There are numerous research and management efforts occurring at this time that should result in the enhancement, re-establishment or at least maintenance of many North American lake sturgeon populations. As with other sturgeon species, recovery efforts targeting lake sturgeon are very long term endeavors that are dependent upon sustained, consistent work, and are very sensitive to negative biological and social perturbations along the way to recovery. The regular sharing or networking of experiences, technology and expertise between those responsible for lake sturgeon propagation, management, recovery, research and enforcement programs greatly enhances the probability that the impact of potential negative disruptions will be lessened.

The lake sturgeon is currently listed as a rare species in the United States because most of its habitat appears to be threatened.

The Aquaculture Industry

Wisconsin Aquaculture Association

The Wisconsin Aquaculture Association supports legalization of lake sturgeon harvest, purchase, sale, barter, trade, possession, control and transportation by private commercial aquaculture operations within Wisconsin. The prohibition on the private commercial aquaculture industry has been in place for many years and the original reasoning behind the ban was sound, but progress over time and improvements in aquaculture technology make it reasonable to remove the current prohibition under state law.

Private commercial aquaculture operations should not be barred from rearing lake sturgeon while the Wisconsin Department of Natural Resources currently performs the practice at state hatcheries. Lake sturgeon are raised for exportation to other states and provinces through agreements signed by the DNR. In addition, tribal hatcheries in Wisconsin are allowed to raise and process lake sturgeon. Finally, state funded research facilities, similar to the University of Wisconsin—Milwaukee Great Lakes Sea Grant Institute, have raised lake sturgeon in the past and have the freedom to raise lake sturgeon in the future.

The Wisconsin Aquaculture Association understands the value lake sturgeon have to Wisconsin as a natural resource, but the potential significance as an economic enhancement to current income for the State's private commercial operators has the Association considering alternatives to Wisconsin's current laws. Lake sturgeon provide two marketable products—meat and caviar. The potential markets for lake sturgeon flesh and caviar have been created through the exploitation of other species of sturgeon for their caviar and flesh. The logical progression of the market is to next consider lake sturgeon caviar and meat as a likely alternatives to the dwindling traditional varieties. The WAA would also like the opportunity to work with the State's stocking programs by providing a habitat to rear lake sturgeon for the purposes of stocking and rehabilitation of the species. Finally, lake sturgeon have the potential to assist trout hatchery systems with the maintenance of raceways.

The Wisconsin Aquaculture Association believes the issue is not about prohibition, but about the ability to raise lake sturgeon and under what conditions. The WAA recommends the organization and establishment of a statutorily defined Lake Sturgeon Commercial Management Board, which will determine the conditions of operation for all commercial lake sturgeon operations in Wisconsin. The working group will consist of: 3 members from the DNR (2 from Fisheries, 1 from Law Enforcement), 2 Tribal members, 1 University of Wisconsin System representative, 3 DATCP members (2 from Animal Health, 1 from Marketing), and 3 members from private commercial aquaculture operations (various regions of the state). The working group would be permanent and have authority determined by the State Legislature. The working group would address all issues related to public and private harvest, purchase, sale, barter, trade, possession, control, and transportation of lake sturgeon in Wisconsin. The working group would convene on a regular basis and be the State's authority on lake sturgeon.

Lake sturgeon are an important biological and economic species for Wisconsin's private commercial aquaculture operators. The status quo is an unacceptable option and the total deregulation of harvest, purchase, sale, barter, trade, possession, control and transportation is

also not acceptable. Consequently, lake sturgeon should be reared under tightly controlled situations.

The Wisconsin Aquaculture Association is prepared to address any issue concerning lake sturgeon, including genetics, health, poaching, or "black markets." The WAA is optimistic about an open and honest dialogue between all parties involved and is willing to discuss all options presented. Finally, future regulations must address sound science, economic opportunities, and environmental protection, while continuing the development and enhancement of the species.

Mac Graham
Star Prairie Trout Farm
Chair, Wis. Aquaculture Assn.

Great report, covering all the expected interests, plus a few I didn't expect.

The one I did expect but didn't see was input from DATCP Marketing Division. This is clearly the one area in which an agency can be expected to advocate for the privatization/commercialization case.

Fred Binkowski's report from the Great Lakes WATER Institute was also a surprise. Despite the many years of working together on various issues, he unbelievably cast his vote again toward prohibition and repression. WAA will certainly take this up with him (again) personally, as his false positioning as an advocate for private aquaculture smacks of duplicity. He is in a position of great authority on the issue of sturgeon, and his remarks are generally accurate, as far as they go, with one exception.

In his reason #8 for recommending that ...lake sturgeon...(are) not a species suitable for profitable private commercial operations at the expense of the public sturgeon interest,' he steps way outside his area of expertise. His view that sturgeon have 'limited market potential' is not only incorrect, but contradicts his and others notion regarding potential for 'illegal sale and movement of fish from Wisconsin's remaining wild stocks.' The black-market argument against commercialization is based precisely on the assumption of high market potential. Here in particular, I'd like to see DATCP-Marketing input, as it would carry more weight than my own.

What he fails to recognize is the creative value of private enterprise, which can succeed in many cases where research labs and agency hatcheries fail. The culture-related problems he cites (difficulty in spawning, incubation, and early feeding, water quality importance, slow growth and maturation, etc.) are similar to concerns with other fish species that have been addressed in many cases more effectively by private hatcheries.

The reason is simple, and goes beyond mere profit-orientation. Farmers will sacrifice short-term profits in the interest of longer-term gains, bringing to bear widely different motives, inspirations and perspectives. Not to say the blinders are lifted, just loosened a whole lot. This is especially true when a long-term investment, due to slow growth and maturation, is involved.

Issues of health, escape/confinement, and law enforcement (black marketing) also are met more favorably with a private commercial interest at heart. The simple matter of preventing losses and enhancing growth is obvious. Beyond this, as stewards of the water, fish farmers are more apt to be watchdogs than violators are. As in the allegations of polluting public waters through fish farming, farmers are more likely to inform of violations that negatively impact their waters or markets than they are to do the opposite.

In many ways, the repressive attitude that will deny the opportunity to even make the attempt is the largest single threat to the 'public sturgeon resource.' As with other species of fish, private hatchery enhancement efforts can be more effective than the state equivalent. One needs merely to look at the record to see where hatchery-related fish health problems originate — it's not at the private facilities. Likewise with chemical and antibiotic use and the associated problems of contamination; or needs for employee time and attention — private growers prove over and over again their daily practice of extra labor, extra commitment, extra watchfulness. The potential benefits from creative and constructive privatization in enhancement programs are huge — we just need to be given the chance.

Aquaculture has been unfairly maligned in recent years based on pollution, health and genetic threats, and now greed (black marketing). Yet never has there been a violation in an industry that predates any existing law authority over wildlife and natural resources by many decades. Binkowski's 'public sturgeon resource' has been threatened by many things since man first became involved, but never by aquaculture.

As far as conclusions go, I view the best option as one that recognizes and controls the various risk factors, through either WAA-type committees, or SMAT-type WLSAAs, but allows privatization/commercialization. If all the cultural consideration Binkowski mentions are as prohibitive to commercial culture as he suggests, there will be very little interest to begin with. I'd be surprised if more than five farms in the state show a serious interest, and they will doubtless begin at a very small scale. What risks are assumed by the state in so doing will be more than compensated for through committed efforts by the aquaculture industry in active partnership with state agencies and resource interest groups. Any doubts regarding the level of commitment and honesty the farms represent will be dispelled if those concerned merely make the effort to visit farms and spend some time with Wisconsin fish farmers. We ask just to be given the chance.

Sally Tadda
Poplar River Fishing Park

How does the State of Wisconsin think fish farming (aquaculture) will ever begin to grow, when there is so much competition from our own State agencies? I thought we were going to work together. I thought the powers that be were going to let fish farmers make enough money to at least stay on the land (and pay our TAXES!!!). Pretty soon we will have to hire someone just to do our paperwork. This is another example of not giving fish farmers a way to be competitive with other States that can already sell Lake Sturgeon. Protectionism will only get you extinction of what you are trying to protect. What if something was to happen to the lake sturgeon in the wild?

Jim Michalski
Wisconsin Aquaculture Association

I have finally read and digested the "Regulatory Options for the Commercial Rearing of Lake Sturgeon." That was quite a volume of material. There was maybe too much material. I believe that Appendix II and Appendix III were totally unnecessary, though interesting, were of no value in the discussion of the topic. They could have been left out.

I also have concern with Appendix I. Just the makeup of the "Sturgeon Management Assessment Team" is questionable—15 out of 29 people on the "Team" were DNR staff. The industry had one representative. I think this "Team" was not created to deal with the question of the commercial rearing of lake sturgeon, but rather for dealing with a much bigger topic: The management of lake sturgeon in Wisconsin. To have this many DNR operatives dealing with the commercialization question is at best a waste of manpower. At worst, it appears to be stacking of the deck against the industry.

I also have a problem with the "Sturgeon for Tomorrow" people and question the value of their testimony on this issue. Although they seem like a conservation group, they are in fact a self-serving group made up of sturgeon anglers and businessmen who benefit from sturgeon fishing. Sturgeon for Tomorrow parrots the remarks of the Great Lakes Water Institute, whom they fund to do sturgeon research. They are entitled to their opinion, but I do not see the basis of their expertise. Size and bag limits are really their domain.

The Great Lakes Water Institute and it's senior scientist, Fred Binkowski, have been one of the primary sources of information on lake sturgeon. I have concerns about his testimony. The lake sturgeon has become the exclusive domain of the senior scientist. He has "sturgeon" as his E-mail address. I conclude that ego may be a factor when there is so much negative input by Binkowski. Some of the input seems contrived: "Lake sturgeon remains a difficult species to culture and is not a species suitable for profitable private commercial operations at the expense of the public sturgeon resource because:" He then goes on to give eleven "reasons" why. Unfortunately, the reasons are facts about the culture of sturgeon and not a threat to the "public sturgeon resource." What does the lake sturgeon sensitivity to heavy metals have to do with privatization threatening the "public sturgeon resource?" For that matter, what do reasons one through nine have to do with privatization threatening the "public sturgeon resource?" Reasons ten and eleven have some merit as a threat to the "public sturgeon resource." These threats to the "public sturgeon resource" are already present with the private ownership of lake sturgeon in Minnesota and Michigan. These states do not seem to have any problems with aquarium fish release. It seems that this is the only real threat to the "public sturgeon resource:" Release of aquarium fish into the environment and the spread of disease. I mean, this is like making angling illegal because some misguided soul will release his catch in some other lake and threaten the public resource. By maintaining a private stock of lake sturgeon, private aquaculture could INCREASE the numbers of Wisconsin's remaining wild stocks and guarantee the existence of the species in case of some catastrophe in the public sturgeon population.

I see the Wisconsin Aquaculture Association's proposed working group as having the fairest make up in representation of various interests. With a group as defined in the WAA's proposal, we can have a meaningful and fair discussion of the lake sturgeon question in a forum where all ideas can be presented.

Historically, it has been a struggle for the private fish farmer to make progress in raising new varieties of fish in Wisconsin. Even though there has never been a citation against any fish farmer for pollution or stocking violations, people in the Department of Natural Resources are suspicious of motives and methods. Concern for the environment and the fish stocks of Wisconsin is vital for commercial aquaculture to exist and thrive. I hope that some day these meetings will help the DNR employees realize that the Department of Natural Resources and the private commercial industry are on the same side on conservation issues.

I hope my comments and observations have helped.

Steve DeBaker
Branch River Trout Hatchery

We at Branch River Trout Hatchery have long been interested in the culture of sturgeon species. We have had experience raising sturgeon from 1-2" size up to the 4-5" range. We were given a permit to raise shovelnose sturgeon 4-5 years ago, but since that time we have learned some very interesting things about the species, including that the fish will survive in cold temperatures with trout rearing applications, also that you can start them on virtually the same diet as trout. The main fallacy that some scientists have based their research on simply is not true. It is true that some techniques in rearing are different, but believe me, if it would cost too much to raise these magnificent creatures, we simply couldn't do it. When will the state of Wisconsin give up this most sacred of cows? Most likely, when it is too late to do anything about it. I'm quite sure that you have heard from all the political sides, some for, some against, but speaking as someone who not only raises these fish, but someone that enjoys the pure delight of reaching down in my ponds to literally pet these creatures, I can only tell you that these fish are not hard to raise. They serve a tremendous benefit in my hatchery, and though they take time to mature, like my homemade vintage grape wine, it is well worth the wait. I would only ask that you consider giving the private sector a chance to raise lake sturgeon, not only for their benefit, but to help put back a resource for continuing generations to enjoy. So many of these fish are shipped out of the State of Wisconsin, why not keep this resource here and let private aquaculturists lend in the culture of the historic relics of the past.

Conservation Organizations

Sturgeon for Tomorrow

The Sturgeon for Tomorrow Board of Directors and general membership in cooperation with local businesses of the Fox River Valley have worked for the past 25 years to raise monies to fund sturgeon research and management projects to promote the enhancement of sturgeon stocks. In the late 1970's, Sturgeon for Tomorrow was instrumental in funding the initial research that developed lake sturgeon culture techniques. The techniques have been used in sturgeon management programs in Wisconsin and North America.

Sturgeon for Tomorrow is opposed to the open commercialization of lake sturgeon. The organization believes open commercialization would constitute a serious threat to Wisconsin's native sturgeon stocks. Sturgeon for Tomorrow is concerned with the negative impact an unwanted release of sturgeon from a private operation could pose for Wisconsin's wild native stock, specifically disease transmission and genetic contamination. The concern extends to any aquarium industry involving lake sturgeon, which is related to private industry. Finally, Sturgeon for Tomorrow is uncomfortable with the potential for "black market" wild fish that may result from the diminishing stocks of Russian sturgeon, which produce roe (caviar).

Sturgeon for Tomorrow supports private industry involvement in the rearing of lake sturgeon for rehabilitation purposes, but only under the aquaculture standards developed through implementation of section 8 of the Wisconsin Lake Sturgeon Management Plan. Section 8 outlines lake sturgeon rearing standards for all operations (public and private), that should ensure Wisconsin's wild stocks are maintained and improved.

Sturgeon Management Assessment Team

The Sturgeon Management Assessment Team was established in December 1996 with the purpose of "reviewing, evaluating, and updating lake sturgeon management goals in Wisconsin." Team members include a diverse group of individuals from the Wisconsin Department of Natural Resources, the U.S. Fish and Wildlife Service, the Great Lakes Indian Fish and Wildlife Commission, the Menominee Tribe, the University of Wisconsin System, the aquaculture industry, several private sporting organizations, the sport fishing industry, and the general angling public. SMAT developed Wisconsin's Lake Sturgeon Management Plan to facilitate the preservation, protection, and restoration of lake sturgeon populations in Wisconsin for the benefit of the sturgeon resource and all its users.

On behalf of the Sturgeon Management Assessment Team, we'd like to take this opportunity to provide you with our position on the commercial rearing of lake sturgeon in Wisconsin. We respectfully request that it be incorporated into the Department of Agriculture, Trade and Consumer Protection's and Department of Natural Resources' Regulatory Options for the Commercial Rearing of Lake Sturgeon Report to the Wisconsin Legislature.

Wisconsin is fortunate to possess the largest and healthiest self-sustaining lake sturgeon

population in the world. Consequently, measures should be taken to ensure the viability of those populations remain into the future. Illegal harvest of lake sturgeon can easily decimate targeted stocks, while unwanted releases from an open aquaculture and aquarium industry could seriously hamper recovery efforts due to the introduction of parasites or diseases, and potential dilution of the natural gene pool.

Aquaculture will obviously play an important role in Wisconsin lake sturgeon recovery and enhancement efforts, and private aquaculture should be a partner in these efforts. Both public and private interests involved in this issue though, need to thoroughly discuss and agree upon the strict technical standards for aquaculture that need to be met to ensure the overall success of efforts targeting the management or recovery of the public sturgeon resource. These technical standards have been discussed thoroughly by the Sturgeon Management Assessment Team and are primarily addressed in Sections 3 and 8 of Wisconsin's Lake Sturgeon Management Plan.

The Sturgeon Management Assessment Team advocates that lake sturgeon propagation efforts be conducted with clear, concise, and strict technical standards for research and rehabilitation purposes only. It is our hope that these efforts can include the private aquaculture industry and that everyone can work together to preserve and restore Wisconsin's great lake sturgeon resource.

Wisconsin Wildlife Federation

It was a pleasure meeting you in September at the Sturgeon Management Assessment Team (SMAT) meeting in Stevens Point. The team is made up of a diverse group of people and interests including private aquaculture. I am a citizen member of that team representing the Wisconsin Wildlife Federation. Our organization is opposed to open commercialization of lake sturgeon. We believe that this activity, if allowed, would pose a serious threat to the native sturgeon population.

As a member of the SMAT, we spent many hours arriving at what we feel is a good plan for the future of sturgeon in this state. One section (Section 8) of the Wisconsin Lake Sturgeon Management Plan outlines a process of sturgeon rearing which excludes no one person, or group from lake sturgeon rearing so long as they adhere to the standards set forth in the Plan.

I applaud your time and efforts in preparing your report to the Legislature on the commercial rearing of lake sturgeon. I would also appreciate it if my concerns become a part of that report. I realize this is the eleventh hour but I feel they are important.

Harry Kachur

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The Wisconsin Lake Sturgeon Management Plan

The Sturgeon Management Assessment Team (SMAT) was established in December 1996 with the purpose of "reviewing, evaluating, and updating lake sturgeon management goals in Wisconsin." By reviewing and updating management goals, a logical end product of SMAT's deliberations would be a revised management plan for lake sturgeon in the State of Wisconsin. The plan would be created to preserve, protect, and restore lake sturgeon populations in Wisconsin for the benefit of the sturgeon resource and all its users.

Team members included a diverse group of individuals from the Wisconsin Department of Natural Resources (WDNR), the U.S. Fish and Wildlife Service (USFWS), the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), the Menominee Tribe, the University of Wisconsin—System, the aquaculture industry, several private sporting organizations, the sport fishing industry, and the angling public. Members were invited to participate in the plan development process because of their specific interest in sturgeon biology and management.

A draft management plan was presented to the public in a series of special meetings held throughout the state to give interested citizens the opportunity to provide input on the issues and concerns raised in the management plan. Comments from these meetings were incorporated into the final document.

The completed document follows for your convenience.

Wisconsin's Lake Sturgeon Management Plan

Wisconsin Department of Natural Resources
Bureau of Fisheries Management and Habitat Protection

October 2000

WISCONSIN'S LAKE STURGEON MANAGEMENT PLAN

Table of Contents

EXECUTIVE SUMMARY

The waters of Wisconsin collectively possess one of the largest self-sustaining populations of lake sturgeon, *Acipenser fulvescens*, in the world. Because of the biological characteristics of lake sturgeon (e.g., slow growing, late-to-mature) and the ease in which a population may be negatively altered in an exploited fishery, it is critical that management strategies and philosophies be continually reviewed, refined and updated.

The Sturgeon Management Assessment Team (SMAT) was established in December, 1996 with the purpose of "reviewing, evaluating, and updating lake sturgeon management goals in Wisconsin." By reviewing and updating management goals, a logical end-product of the SMAT's deliberations would then be a revised management plan for lake sturgeon in the state of Wisconsin. Team members included a diverse group of individuals from the Wisconsin Department of Natural Resources (WDNR), the U.S. Fish and Wildlife Service (USFWS), the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), the Menominee Tribe, the University System, the aquaculture industry, several private sporting organizations, the sport fishing industry, and the angling public. Members were invited to participate in the plan development process because of their specific interest in sturgeon biology and management.

Through several facilitated workshops, the Sturgeon Management Assessment Team identified the following key statewide lake sturgeon management issues: the decline in abundance over the last century, the absence of comprehensive biological and/or harvest information with which to manage populations at a statewide or watershed level, the negative effect that habitat loss, modification, or inaccessibility has had on populations, the maintenance of genetic diversity and long-term health of rehabilitated populations, the importance of protection from illegal harvest or incidental catch, the absence of a mechanism to ensure that genetic variability and other population characteristics are maintained in commercial or private industry activities, the existence of antiquated policies and management goals, and the essential involvement of the general public in an effective management program. From the above list of management issues, the Team recommends the following actions:

- Develop standardized collection techniques for population, reintroduction, catch, and harvest assessments
- Identify critical seasonal habitats and habitat improvement opportunities
- Review stocking and reintroduction proposals to ensure genetic integrity is maintained
- Create a separate license fee for hook and line sturgeon fisheries
- Restrict all sturgeon species propagation to the state of Wisconsin and federal, tribal, and commercial aquaculture under a cooperative agreement for research and rehabilitation
- Implement the statewide Lake Sturgeon Management Plan

A draft management plan was presented to the public in a number of special meetings to give interested citizens the opportunity to provide input on the issues and concerns raised in the management plan. Comments from these meetings were incorporated into this final document.

This Lake Sturgeon Management Plan was created to preserve, protect, and restore lake sturgeon populations in Wisconsin for the benefit of the sturgeon resource and all its users.

LAKE STURGEON MANAGEMENT ISSUES

The following issues were identified by the Sturgeon Management Assessment Team as the most crucial to the future of sturgeon management in Wisconsin.

A. ***There is a need for biological information on sturgeon/dynamics to effectively manage these species on a statewide or watershed basis.***

Information is often used to make a variety of management and regulatory decisions. Often times, the lack of sufficient population information hinders species-specific management goals. An information void currently exists on many sturgeon populations in Wisconsin. Population level information on the majority of our river systems is lacking and the importance of this species early life history requirements for successful recruitment is unclear. The perpetuation of self-sustaining stocks of sturgeon require a comprehensive understanding of their biology, population dynamics, habitat needs, movement and migration patterns, water quality requirements, fisheries interactions, and the short and long-term effects of human induced impacts. All aspects of target populations must be adequately assessed if this species is to be effectively managed in the future.

B. ***Habitat loss, modification, or inaccessibility have negatively affected sturgeon populations.***

The availability of critical habitats (e.g., spawning, nursery, overwinter) is often the most important factor in the success of any fish population. When these habitats are lost or modified in some way, the resulting impacts can have a direct effect on specific populations. The majority of Wisconsin's river systems have been modified by dam construction that has simplified and fragmented riverine habitats. Water level fluctuations no longer mimic the hydrography of natural river systems. Historical spawning runs no longer occur because of the barrier effect of dams. Riparian development and the resulting sediment deposition and water quality changes have significantly reduced habitat diversity. Fish species such as lake sturgeon have had their distributions dramatically altered by river modification. For this species to continue to exist and flourish, it will be necessary to mitigate current conditions by providing passage opportunities at dams, reducing the occurrence and intensity of unnatural water level fluctuations, or by sustaining or improving river habitats and wetlands that are conducive to reproduction, growth, and survival.

C. ***The genetic diversity and long-term health of rehabilitated sturgeon populations must be maintained.***

Interbasin transfers of fish stocks has undergone considerable scrutiny over the years because of concerns over genetic integrity. Recent assessments support the existence of several genetically distinct stocks of fish in Wisconsin. Individual strains or subpopulations may exhibit unique adaptations to their specific habitats so it is imperative that the complete realm of genetic implications are considered when proposing or implementing any propagation or stocking activity. Genetic diversity in hatchery reared fish must be maintained and maximized if at all possible.

D. ***There is a need for harvest and exploitation information on sturgeon to effectively manage this species on a statewide or watershed basis.***

Information is often used to make a variety of management and regulatory decisions. Often times, the lack of sufficient harvest and exploitation information hinders species-specific management goals. Information is lacking on several crucial aspects of the hook and line sturgeon fishery in Wisconsin

(e.g., catch statistics, exploitation rates, sex/age structure). Also the understanding of length limits and their impact on size, age, and sex structure of sturgeon fisheries with both hook and line and spearing is unclear. Because of the nature of the species (long-lived, late-to-mature) it is clear that management decisions must be based on as accurate and complete information as possible. Every opportunity to assess sturgeon fisheries must be taken.

E. ***Sturgeon populations have been reduced in many Wisconsin waters over the last 100 years.***

Over the years, sturgeon populations (or portions of populations) have declined because of habitat degradation, dam construction, water quality problems, and possibly overharvest. In an effort to maintain viable populations and associated fisheries, sturgeon have been intensely managed in some areas and specifically reintroduced for restoration purposes in others. Although reintroduction efforts are satisfying the ultimate goal of "reestablishing sturgeon in waters within their original range where there is reasonable possibility of developing self-sustaining populations through natural reproductions," the impacts to the aquatic community are unknown. Biologically sound population goals should be established for sturgeon populations.

F. ***Sturgeon populations must receive adequate protection from illegal harvest or from incidental catch in commercial fisheries. Additionally, the current registration system is not a complete assessment tool and should be modified to provide additional information.***

Sturgeon management goals can never be realized without enforcement support. Because most sturgeon typically make extensive migrations, they may be exposed to illegal harvest at a variety of locations. Enforcement activity must remain strong if populations are to be adequately protected. Illegal harvest can have significant impacts on the remaining population. Because commercial fishing operations harvest hundreds of thousands of pounds of fish on an annual basis, incidental catch of sturgeon will always be of concern. Moreover, while the spearing registration system has been developed and modified over a number of years, the hook and line sturgeon registration process is in its infancy and may need to be reviewed and revised to provide additional harvest information.

G. ***Understanding, support, and involvement by the general public is essential to an effective management program.***

Information, education, and public involvement is critically important when trying to gain the needed support for any proposed management activity. Knowledge of the uniqueness of sturgeon populations is necessary to the understanding of goals and the establishment of management priorities. Increased public awareness and knowledge also facilitates compliance of the current regulatory framework. Public involvement, understanding and support are critical components in the long-term success of sturgeon management in Wisconsin.

H. ***There is no mechanism to fully evaluate or ensure that genetic variability and other population characteristics are maintained in commercial or private industry activities.***

Sturgeon are unique species with regards to longevity, spawning maturity, intolerance to pollution, etc. Consequently, genetic mixing, disease, and parasite infection, etc. could severely impact wild populations. Unlike most traditional species that may only require a few years to recover, recovery of a sturgeon population may take between one and two generations. Although private rearing and introductions may supplement existing populations and fisheries, it is imperative that the feasibility of such actions be completely evaluated before accepting this policy.

I. ***The lack of adequate statewide management goals and policies have impaired the progress of sturgeon management in Wisconsin.***

Generally, the effective management of a particular species revolves around the presence and implementation of a concise management plan that identifies issues and problems and the associated strategies to address each of them. To date, such a complete management plan does not exist for sturgeon in Wisconsin. In some cases, the absence of a plan has impaired management of the species. A sturgeon management plan developed through a coordinated planning effort with agency, govern mental, university, tribal, and private interests will elevate the concerns regarding sturgeon management to the appropriate administration and will provide a framework for decision making in the future.

OBJECTIVES AND MANAGEMENT RECOMMENDATIONS

Through several facilitated workshops, members of the Sturgeon Management Assessment Team identified several key objectives for successful sturgeon management and listed a variety of recommendations that would ultimately meet those objectives. The recommendations listed below have been given a priority order by being assigned either a high (H), medium (M), or low (L) designation.

1.0 Sturgeon Population and Life History Information Needs

Objectives
- 1.1 Maintain/enhance current sturgeon population assessments
- 1.2 Develop and implement standardized population assessments on all existing populations
- 1.3 Conduct life history research/assessments where needed

Recommendations
- a. Develop as standardized collection techniques as possible to conduct population studies (estimates, age/growth, size structure, etc.) (H)
- b. Establish a priority list of waters that need assessment work (H)
- c. Assess success of reintroductions by methods identified in Objective 1.2 (H)
- d. Identify characteristics that correlate with successful reproduction and recruitment (e.g., fungus mortality of eggs, predation on various life stages, assessment of spawning grounds) (M)
- e. Identify seasonal migration patterns (M)
- f. Identify natural sex ratios (M)
- g. Assess homing and imprinting behavior (M)
- h. Identify other research needs as appropriate (M)
- I. Search for remnant populations (L)

2.0 Habitat Protection and Enhancement

Objectives
- 2.1 Identify critical habitats and habitat requirements for various life stages
- 2.2 Identify barriers and other factors within systems negatively affecting sturgeon populations
- 2.3 Enhance habitat where possible

Recommendations
- a. Identify critical seasonal habitats and improvement opportunities (H)
- b. Ensure the impacts of dams and habitat needs of species are considered during the FERC relicensing process (H)

c. Work with dam owners to effectively manage or improve habitat in fragmented river systems. Consider dam removal, if warranted, to reconnect fragmented populations. Educate public on the impacts of dams and benefits of dam removal. (H)
d. Use proper flow management at dams to benefit species (including development of appropriate HSI curves for various life stages) (H)
e. Use washed rock riprap (>6") as material to create new or supplement existing spawning habitat (H)
f. Provide passage at dams where feasible and where passage would benefit sturgeon populations (H)
g. Discourage riparian uses that negatively affect populations (H)
h. Encourage riparian uses that benefit populations (M)
I. Evaluate habitat improvement projects (M)
j. Complete Wolf River sturgeon spawning substrate and flow study report (M)
k. Determine water quality needs for populations (L)

3.0 Genetics and Propagation, Transfers, and Reintroduction

Objectives

3.1 Define existing strains/populations and role of genetics in management and rehabilitation or reintroduction
3.2 Ensure statewide commitment and coordination of sturgeon propagation programs
3.3 Maximize genetic variability in hatchery reared fish used for rehabilitation or reintroduction
3.4 Establish best technical criteria and protocol for maximum quality assurance in propagation efforts

Recommendations

a. All stocking and reintroduction proposals be reviewed by Sturgeon Management Assessment Team (H)
b. Use similar strains within basin for stocking and transfers, unless extirpated in the basin (H)
c. Form a committee to establish genetic hatchery guidelines, standards, and technical criteria for the propagation of lake sturgeon. (follow existing guidelines until own guidelines can be developed) (H)
d. Acclimate fish to water body prior to release (H)
e. Annually stock at the suggested minimum densities for rehabilitation purposes for a recommended duration of 25 years of:

Fry	Fingerlings		Yearlings
Based on availability	River	80 per mile	40 per mile
and objectives	Lakes	1 per 2 acres	1 per 4 acres

These recommended rates were based upon estimated population densities of the Menomonee River (for the river rates) and Lake Winnebago (for the lake rates). The historical estimated population densities in both waters were used as starting points from which the number of fingerlings and/or yearlings needed on an annual basis to effect a complete recovery of the stock, were estimated. The true effectiveness of the implementation of these rates has not been tested and will need to be evaluated as lake sturgeon rehabilitation projects proceed. For rehabilitation of extirpated or severely depressed stocks, it is recommended that annual stocking occur for at least 25 years or one generation of a lake sturgeon population. Well designed stocking evaluations conducted during that time period will provide the data necessary to adjust the stocking rates as needed to result in the ultimate densities desired for the target water.

Priority List of Wisconsin Lake Sturgeon Rehabilitation Waters - The Sturgeon Management Assessment Team categorized the following waters as priorities in the lake sturgeon rehabilitation process:

A. Waters with ongoing restoration efforts:

- The Wisconsin River from Stevens Point to Lake Du Bay
- The Menominee River below Sturgeon Falls
- The Upper Flambeau River - Manitowish River system
- The St. Louis River
- The Bad River
- Menominee Reservation Waters - Middle Wolf River System; Legend Lake
- St. Croix/Namekagon River System

B. Waters in which rehabilitation can begin:

- The Upper Fox River from Princeton to Lake Butte des Morts
- Green Bay and its tributaries

C. Other potential rehabilitation waters (will need more information, plan development, etc. before rehabilitation efforts can begin):

- Lake Michigan and its tributaries
- Lake Superior and its tributaries
- Lac du Flambeau Reservation waters
- Red Cedar River
- Mississippi River

4.0 Harvest and Fisheries Information Needs

Objectives 4.1 Develop and implement standardized exploitation assessments

Recommendations

a. Develop standardized catch/harvest assessment techniques that include a measure of exploitation, effort, and age, size, and sex of fish (registrations, rotational creel surveys) (H)
b. Determine incidental catch and harvest of sturgeon in commercial fishing operations (identify areas open to commercial fishing contracts that may be closed in future) (H)
c. Continue Winnebago spearing assessment (H)
d. Examine impact of regulations (length limits, season, etc.) on spearing and hook and line fisheries (H)
e. Conduct literature review on exploitation of sturgeon fisheries (M)
f. Determine hooking mortality of sturgeon (M/L)
g. Determine impact of barriers that concentrate fish and increase harvest (L)
h. List chronology of sturgeon regulations (L)

5.0 Population Densities

Objectives 5.1 Manage lake sturgeon populations with biologically and conservationally sound goals.
5.2 Reestablish sturgeon throughout their former range

Recommendations

a. Manage for densities of Age 2+ fish at 250 fish/mile in inland rivers and 1.5 fish/acre in lake systems. (combination in flowages). Populations should be ideally represented by males up to 40 years of age and females up to 70 years of age.

6.0 Regulations and Enforcement

Objectives

6.1 Manage average annual exploitation of populations at or near 5%
6.2 Maintain strong enforcement of sturgeon regulations at all times
6.3 Protect remnant and rehabilitating sturgeon populations

Recommendations

a. Create separate licensing fee structure for H/L sturgeon fisheries (H)
b. Designate all monies collected from sturgeon licensing be used for sturgeon management and assessment work (H)
c. Standardize license and carcass tag procedures between spearing and hook and line (Tyvac tag, fee, registration procedure/information collection) (H)
d. Evaluate current minimum length limits and expand harvest assessment to make recommendations by 2002 (H)
e. Remove remnant populations from hook and line harvest opportunity (H)
f. Incorporate the hook and line sturgeon tag into the Automated License Issuance System (ALIS) (H)
g. Implement Oct. 1 license sale deadline for Winnebago spearing license (H)
h. Examine the possibility of requiring a "harvest" tag or quota system to manage harvest on hook and line fisheries (H/M)
i. Work with tribal interests to review and compare tribal and nontribal sturgeon harvest (H/M)
j. Develop one statewide sturgeon regulation and information pamphlet (tip card, etc.) (M)
k. Review boundary water regulations and promote regulation consistency (M)
l. Continue Fox/Wolf River "sturgeon patrol" and encourage other patrols on other waters (M)
m. Ensure and enhance FH/LE integration on sturgeon issues (M)

7.0 Public Input and Involvement

Objectives

7.1 Maintain proactive public involvement in sturgeon management
7.2 Develop and implement statewide public education program for sturgeon and sturgeon management

Recommendations

a. Maintain Sturgeon Management Assessment Team to implement and update Sturgeon Management Plan and review ongoing management activities (H)
b. Develop and implement local public involvement where necessary (Sturgeon Advisory Committee, Sturgeon for Tomorrow, etc.) (H)
c. Identify target audiences for sturgeon information, type of information and exchange needed, and develop appropriate educational materials to meet identified needs (e.g., video, posters, curricula, exhibits) (H)
d. Create web page that will surve as a clearinghouse for sturgeon information and education in Wisconsin. (H)
e. Produce annual sturgeon harvest and management report that includes information on spearing, hook and line, and tribal harvest (H)
f. Draft fact sheet of Sturgeon Management Plan to distribute with hook and line tag applications and sturgeon spearing licenses. (H)
g. Work with local interests to create Sturgeon for Tomorrow chapters through out the state (M)

8.0 Commercialization, Privatization, and Scientific Use of Sturgeon Resources

Objectives

8.1 Minimize/eliminate potential problems and threats from aquaculture operations and scientific users.

8.2 Prohibit the importation and distribution of all sturgeon species as a hobby fish for aquaria.

8.3 Establish a cooperative partnership agreement between the Department of Natural Resources, USFWS, Department of Agriculture, Trade, and Consumer Protection (DATCP), academia, tribes, other agencies, and the commercial aquaculture industry for the propagation of lake sturgeon, hereafter referred to as the Wisconsin Lake Sturgeon Aquaculture Agreement (WLSAA) using established technical criteria (from Objective 3.4) to assure the production of the highest quality product.

Recommendations

a. Restrict all sturgeon species propagation to DNR, USFWS, DATCP, tribal, academia, and commercial aquaculture under a WLSAA agreement for research and rehabilitation (statute change) (H)

b. Prohibit live sturgeon and/or gametes on any license except under the WLSAA agreement (H)

c. Require a scientific collector permit application for those interested in collecting and conducting research on sturgeon. A complete study proposal or plan of work with the following sections should be submitted with the application: Background, Objectives, Approach, Expected Results, Application of Results, References, and Qualifications of Participants. Additionally, applicants will be required to submit annual reports on their progress and a complete report on their project results within 90 days of project completion. Applications will be reviewed by 1) the local fisheries biologist, and 2) the Sturgeon Management Assessment Team. Note: Research cooperators are expected to conform to above reporting standards (H)

d. Use technical criteria for propagation established in Objective 3.0 in the development of the WLSAA agreement. (H)

e. Determine current jurisdictions and authorities

9.0 Management Plans

Objectives

9.1 Develop, implement, and update as needed a statewide sturgeon management plan for Wisconsin

Recommendations

a. Implement statewide sturgeon management plan (H)

b. Develop and implement drainage and water specific management plans (H)

c. Ensure sturgeon management recommendations are addressed in WDNR watershed or basin management plans (H)

d. The Sturgeon Management Assessment Team should meet annually to assess implementation of Plan and conduct plan updates when necessary (H)

e. Central Office fisheries liaison should be responsible for overseeing the implementation of the statewide sturgeon management plan and coordinating activities of the Sturgeon Management Assessment Team (M)

IMPLEMENTATION STRATEGY

Cooperative efforts between multiple agencies and interested publics will assist in implementing the Wisconsin Lake Sturgeon Management Plan. Ultimately, this plan will be administered by the Department of Natural Resources, through the Bureau of Fisheries Management and Habitat Protection, and through joint projects and partnerships with public and private groups and other individuals interested in sturgeon management.

The Sturgeon Management Assessment Team will continue to function as a recognized team, representing a cross section of various sturgeon interests. The Department of Natural Resources or other responsible agencies, working with the public, will determine the feasibility of and develop cost estimates for implementation of various management options suggested in the Plan.

The Wisconsin Lake Sturgeon Management Plan is a management guide developed through the work of dedicated groups and individuals having a stake in the long-term management of sturgeon and other aquatic resources of the State of Wisconsin. This plan will be an ever-evolving one that will be implemented by people who enjoy and depend on the recreational, cultural, and commercial opportunities offered by Wisconsin's sturgeon resource.

THE STURGEON MANAGEMENT ASSESSMENT TEAM

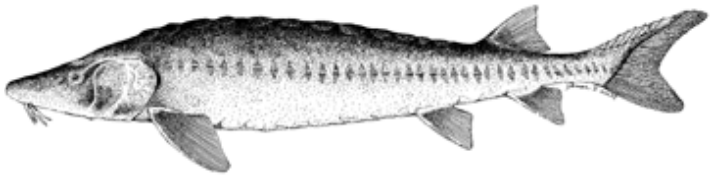
Name	Affiliation
Ron Bruch	WDNR Fisheries and Habitat- Oshkosh
Fred Binkowski	UW-Milwaukee, Great Lakes Research
Gerry Bever	WDNR Fisheries and Habitat - Park Falls
Mark Brann	WDNR Law Enforcement - Eau Claire
Bill Casper	Sturgeon for Tomorrow
Doug Cox	Menominee Tribe
Larry Damman	WDNR Fisheries and Habitat - Spooner
Steve Fajfer	WDNR Fisheries and Habitat - Wild Rose
Tim Gollon	Gollon Bait Company, Dodgeville
Steve Hewett	WDNR Fisheries and Habitat - Madison
Dennis Jones	WDNR Law Enforcement - Oshkosh
Chuck Judd	Judd's Marina, Poynette
Harold Kachur	Wisconsin Wildlife Federation
Joe Kurz	WDNR Fisheries and Habitat - Chippewa Falls
Tim Larson	WDNR Fisheries and Habitat - Poynette
Glenn Miller	Great Lakes Indian Fish and Wildlife Commission
Jeremy Pyatskowit	Menominee Tribe
Henry Quinlan	USFWS - Ashland FRO
Don Reiter	Menominee Tribe
Jeff Roth	WDNR Fisheries and Habitat - Mercer
Ann Runstrom	USFWS - La Crosse FRO
Butch St. Germain	Lac du Flambeau Tribe
Karl Scheidegger	WDNR Fisheries and Habitat- Madison
Steve Schlimgen	WDNR Law Enforcement - Poynette
Streve Schram	WDNR Fisheries and Habitat - Bayfield
Steve Thompson	Winnebago Sturgeon Advisory Committee
Tom Thuemler	WDNR Fisheries and Habitat - Peshtigo
Larry Wawronowicz	Lac du Flambeau Tribe
Jack Zimmerman	WDNR Fisheries and Habitat - WI Rapids

BIOLOGY AND STATUS OF LAKE STURGEON IN WISCONSIN

The following biology and life history characteristic information has been taken from Becker (1983).

LAKE STURGEON

Description - . Body heavy, torpedo-shaped, angular (5-sided) in young, but round in adults. Total length of adults around 45" or more. Snout short, conical. Spiracle present. Caudal peduncle short, stout, partly naked. Lower lip with 2 lobes. Barbels on lower snout, smooth (4). Upper lobe of tail fin pointed without threadlike (filamentous) extension (compare with shovelnose sturgeon). Young gray or brown dorsally with dusky dorsal and lateral blotches. Adults gray to olivaceous dorsally, white ventrally.



Lake sturgeon, *Acipenser fulvescens*

Distribution and Populations Status. - The lake sturgeon occurs in the Mississippi, Lake Michigan, and Lake Superior drainage basins. In the Mississippi River drainage it occurs in the Mississippi, St. Croix, Chippewa (and major tributaries), and Wisconsin rivers. In the Wisconsin River, records place it upstream to the Castle Rock Flowage (Adams County).

In Lake Superior it is found in the comparatively shallow waters of Keweenaw Bay, in the vicinity of the Apostle Islands, and it is known to spawn in the Bad River (Ashland County). It has been occasionally taken in St. Louis Bay. In the Lake Michigan basin it occurs in Green Bay, Lake Michigan, the Menominee River upstream to the White Rapids Dam, the Fox River upstream to Lake Puckaway, and the Wolf River upstream to Shawano. This system includes Lakes Winnebago, Butte des Morts, and Winneconne, and the Embarrass River. It has been introduced to lakes where natural reproduction did not occur, among them: Big Cedar Lake (Washington County), the Madison lakes (Dane County), Chain of Lakes (Waupaca County), and Pear Lake (Washburn County).

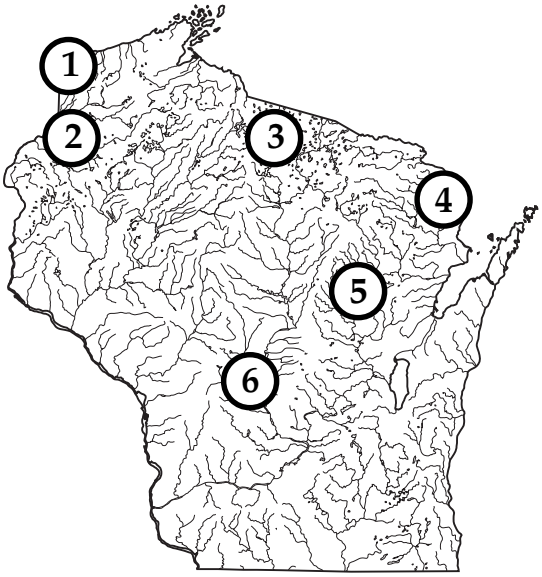
The lake sturgeon is listed as a rare species in the United States. Over most of its range in the United States, it appears to be threatened. In Wisconsin, it is common in the Menominee River, the lower Wolf River, Lakes Poygan and Winnebago, Lake Wisconsin, the St. Croix River to Gordon Dam, Namekagon River below Trego Dam, and the Chippewa and Flambeau rivers. It is uncommon to rare in the lower Wisconsin River, Mississippi River, the Madison lakes, and Lakes Michigan and Superior. The Wisconsin Department of Natural Resources has given the species “watch” status.

Distribution of lake sturgeon, Acipenser fulvescens, in Wisconsin as reported by Greene (1935)

Biology and Habitat. - The lake sturgeon is a typical inhabitant of large rivers and lakes. It lives in shoal water in the Great Lakes. Inland it shows a preference for the deepest midriver areas and pools.
Biology. - Spawning takes place during late April and early May in central Wisconsin. In the St. Croix River, spawning migrations occur in May and early June. In the Wolf River, during seasons when water flow is high and water temperatures rise slowly, spawning begins when the water temperatures reach 53 F. During other times, spawning may not occur until water temperatures reach 58-59 F.
Males are observed at the spawning sites before the females. They cruise the spawning area in groups of eight or more fish, and are frequently so close to the bank that they can be readily captured. Spawning begins as soon as a ripe female enters the group. Several males attend one female by swimming along side her in the same direction, usually against the current. Once spawning takes place, one or more males vibrate simultaneously alongside a female. The average spawning act lasts about 5 seconds. The spawning activity of one female may last from 5 to 8 hours, but may extend over a period of a day or more. Males release milt at the same time the eggs are extruded. Spawning may occur in water from 1 foot up to 15 feet. The eggs are black in color and very adhesive (3 mm in diameter). There is variation in the number of eggs produced by females - anywhere from 50,000 to 700,000 eggs may be released.

Hatching time for the eggs is a function of water temperature. Hatching may occur in 8 days at temperatures of 55-57 F., or in as little as 5 days at water temperatures in the low 60's F. Young sturgeon are nearly 8 mm at hatching and up to 21 mm (almost an inch) at 16 days post hatch.
A female lake sturgeon reaches sexual maturity when she is 24-26 years old and about 55 inches long. Thereafter, instead of spawning every spring, females spawn once every 4-6 years. Few males mature before they are 45" long. Most males spawn every other year. In Wisconsin, male and female sturgeon grow at the same rate, but females live longer than males.

Lake sturgeon travel in loose aggregations, leaving them only at the time of spawning. Occasionally they will move downstream over a dam or a series of dams outside of their home basin.



Lake Sturgeon Restoration Areas

1. St. Louis River
2. Yellow River
3. Upper Flambeau/ Manitowish River
4. Menominee River
5. Wolf River
6. Middle Wisconsin River

Restoration Opportunities. - Over the years, sturgeon populations have declined due to habitat degradation, dam construction, water quality problems, and possibly overexploitation. Efforts to manage, conserve, and restore sturgeon populations have been conducted by the U.S. Fish and Wildlife Service, individual States, Tribes, interstate fisheries commissions, public agencies, universities, and private aquaculture interests. Wisconsin's current lake sturgeon management guidelines call for the "restablishment of lake sturgeon in waters within their original range where there is a reasonable possibility of developing self-sustaining populations through natural reproduction", and to "cooperate with other states in their efforts to reestablish lake sturgeon populations in appropriate waters within their original range."

Currently, there are a number of ongoing restoration efforts involving lake sturgeon populations in Wisconsin:

- **St. Louis River**. - The St. Louis River has received either lake sturgeon fry, fingerlings, and yearlings from the WDNR and Minnesota Department of Natural Resources since the mid 1980's. Because of genetic concerns with the stocking of fish from outside the Lake Superior basin (Wolf River fish, in this case), the restoration efforts were curtailed for several years. Since the mid to late 1990's sturgeon have been propagated in cooperation with the Michigan Department of Natural Resources from the Sturgeon River, an intrabasin source. In 1998, almost 7,000 fingerling sturgeon were stocked by Wisconsin with an additional 7,000 fingerlins given to Michigan for their restoration efforts. In 1999, lake sturgeon were once again propagated and the resultant fry were stocked into the St. Louis River.

- **Yellow River**. - The Yellow River is a tributary to the St. Croix River that flows into Yellow Lake, the current location of the state hook and line record lake sturgeon (170 lbs. 10 oz. caught in 1979). In 1995, the Department reared and stocked 10,000 fry and 13,400 fingerlings into the Yellow River. Efforts are still ongoing to supplement the Yellow River/Yellow Lake population.

- **Upper Flambeau/Manitowish River system**. - Limited spawning by lake sturgeon has been documented in the Manitowish River. Consequently, attempts are being made to collect and spawn fish from the North Fork of the Flambeau River and stock the fry and fingerlings into the Manitowish River. Brood stock were collected from the Manitowish River in 1998 and 24,000 fingerlings were stocked back into the river.

- **Menominee River**. - The Menominee River has been fragmented by dam construction thereby effectively separating and isolating sturgeon populations. There is a 21-mile section of the river from Sturgeon Falls to the Chalk Hill Flowage that historically had lake sturgeon, but have since been extirpated

because of upstream pollution problems. The water quality has been restored in this section of the river but lake sturgeon have not been able to repopulate the section because of downstream dams. Restoration efforts in cooperation with the Michigan Department of Natural Resources have been ongoing in this section since 1982. Over the last five years, about 25,000 fingerlings and yearlings have been reared and stocked (9,900 fingerlings in 1995, 2,400 fingerlings in 1997, 5,000 fingerlings and 600 yearlings in 1998, and 8,000 fingerlings in 1999).

- **Wolf River**. - The Department is currently cooperating with the U.S. Fish and Wildlife Service and the Menominee Indian Tribe on implementing a lake sturgeon management plan for Menominee Reservation waters. The plan is an attempt to establish and maintain quality habitat and a viable lake sturgeon population on the reservation. Juvenile and adult sturgeon have been transferred since the mid 1990's.

- **Middle Wisconsin River**. - Efforts to restablish lake sturgeon in the middle Wisconsin River (Castle Rock and Stevens Point flowages) have been underway since 1991. About 200 juvenile and adult sturgeon (27" - 44") were initially transferred from Lake Wisconsin during 1991-1992. Adult transfers were suspended in 1993 because of concern over the population in Lake Wisconsin. Recently, WDNR crews have been able to collect and spawn sturgeon from the lower Wisconsin River, rear the fry at the Wild Rose Hatchery, and stock then back into the flowages.

LAKE STURGEON IN WISCONSIN: A NATIVE AMERICAN PERSPECTIVE

Lake sturgeon has been utilized by Native American peoples in Wisconsin for centuries prior to European settlement. Many tribes in northern and eastern Wisconsin held lake sturgeon in high esteem as an important source food each spring, and, as such, the fish also became quite religiously significant.

The Menominee Tribe of Wisconsin specifically has a long history of lake sturgeon utilization for various cultural and spiritual purposes. Each spring the Tribe would celebrate the return of Wolf River lake sturgeon to spawning grounds on the Reservation near Keshena Falls by holding a special ceremony to mark the beginning of new life. The building of hydropower dams on the Wolf River below the Reservation in the late 1800's prevented the sturgeon from reaching Keshena Falls and throughout the 20th century few if any sturgeon were seen in the Wolf River on the Menominee Reservation. In the early 1990's the Menominee Tribe, along with the WI DNR and the USFWS developed and implemented the Menominee Reservation Lake Sturgeon Management Plan, which has since re-established sturgeon in most reservation waters and has re-established the connection between the lake sturgeon and the Menominee Tribe. This plan embodies many of the principles of the Wisconsin Lake Sturgeon Management Plan and will be a good complement to recovery efforts initiated elsewhere in Wisconsin through the statewide plan.

Adaptive Disease Management Strategies for the Endangered Population of Kootenai River White Sturgeon

Abstract

For the endangered Kootenai River white sturgeon (Acipenser Transmontanus Richardson) population, conservation aquaculture was identified as a prudent and necessary recovery tool due to the biological status of the population and the demonstrated uncertainties of other recovery efforts. Conservation aquaculture programs need to address potential impacts on the genetic variability, artificial selection, and effects of disease on the native population prior to development and implementation of the program. Available scientific information should be used to develop management strategies that minimize the transmission of disease from cultured fish to native fish and the potential severity of disease in the native population. The white sturgeon iridovirus (WSIV) is the most prevalent viral pathogen of the white sturgeon relative to its distribution and frequency of occurrence, and may be endemic to wild white sturgeon populations throughout the Pacific Northwest. This case study illustrates the importance of conservation aquaculture programs in certain fishery situations. In addition, we discuss how management strategies must remain flexible and must adapt to current available scientific information to provide maximum benefits. Management of the Kootenai River white sturgeon population represents a model cooperative effort of the professional fisheries scientists from private industry; academia; Native American tribes; and provincial, state, and federal government agencies. This cooperation is an essential prerequisite for successful achievement of the program goals. Cooperation is also necessary adaptation of management strategies as information is developed.

ENDANGERED SPECIES–MANAGEMENT

Adaptive Disease Management Strategies for the Endangered Population of Kootenai River White Sturgeon

By Scott E. LaPatra, Susan C. Ireland, Joseph M. Groff, Kathy M. Clemens, and John T. Siple

ABSTRACT

For the endangered Kootenai River white sturgeon (*Acipenser transmontanus* Richardson) population, conservation aquaculture was identified as a prudent and necessary recovery tool due to the biological status of the population and the demonstrated uncertainties of other recovery efforts. Conservation aquaculture programs need to address potential impacts on the genetic variability, artificial selection, and effects of disease on the native population prior to development and implementation of the program. Available scientific information should be used to develop management strategies that minimize the transmission of disease from cultured fish to native fish and the potential severity of disease in the native population. The white sturgeon iridovirus (WSIV) is the most prevalent viral pathogen of white sturgeon relative to its distribution and frequency of occurrence, and may be endemic to wild white sturgeon populations throughout the Pacific Northwest. This case study illustrates the importance of conservation aquaculture programs in certain fishery situations. In addition, we discuss how management strategies must remain flexible and must adapt to current available scientific information to provide maximum benefits. Management of the Kootenai River white sturgeon population represents a model cooperative effort of professional fisheries scientists from private industry; academia; Native American tribes; and provincial, state, and federal governmental agencies. This cooperation is an essential prerequisite for successful achievement of the program goals. Cooperation also is necessary for adaptation of management strategies as information is developed.

Background

The white sturgeon (*Acipenser transmontanus* Richardson) population in the Kootenai River was listed as endangered 6 September 1994 (U.S. Fish and Wildlife Service [USFWS] 1994) under the authority of the U.S. Endangered Species Act of 1973. The Kootenai River population is one of several land-locked populations of white sturgeon found in the Pacific Northwest. Its distribution extends from Kootenai Falls, Montana—located 50 river km below Libby Dam—downstream through Kootenay Lake to Corra Linn Dam on the lower West Arm of Kootenay Lake, British Columbia (Figure 1). A natural barrier at Bonnington Falls downstream of Kootenay Lake has isolated the white sturgeon in the Kootenai system from other white sturgeon in the Columbia River basin since the last glacial age approximately 10,000 years ago (Northcote 1973). The population was listed as endangered due to two decades of nearly undetectable recruitment, declining population size, and habitat degradation and destruction (USFWS 1996). The last substantial year-class was naturally produced in 1974.

Construction of Libby Dam impounded the Kootenai River near Libby, Montana, forming Lake Koocanusa. Operation of Libby Dam has drastically altered the hydrograph, thermal regime, and downstream nutrient-loading rates in the Kootenai River (Apperson and Anders 1991). This may have reduced natural recruitment. Research has confirmed natural spawning in six of the past seven years (USFWS 1998). In 1995 the population of adult white sturgeon in the Kootenai River was estimated to be 1,469 individuals (Paragamian et al. 1996). Natural recruitment was estimated to be 1% of the population since 9 years of sampling recovered only 16 white sturgeon less than 22 years of age (Paragamian et al. 1995). Because white sturgeon do not mature until almost age 20, the equivalent of one full generation in the white sturgeon life cycle had been lost.

U.S. and Canadian regional agencies and the Kootenai Tribe formed the Kootenai River White Sturgeon

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Technical Committee in June 1992 to address the future viability of the species. The Committee was unable to negotiate a Conservation Agreement to implement strategies to prevent the extinction of the Kootenai River white sturgeon. Subsequently, the fish was listed as endangered in 1994. In 1995 the USFWS convened a recovery team to outline strategies needed to recover the species. Because the species range is transboundary, the recovery team included members with technical expertise from the USFWS; Kootenai Tribe of Idaho; Idaho Department of Fish and Game; Montana Fish, Wildlife, and Parks; U.S. Army Corps of Engineers; Bonneville Power Administration; British Columbia Ministry of Environment, Lands, and Parks; and Canadian Department of Fisheries and Oceans. The team concluded that recovering the species depended on reestablishing natural recruitment, minimizing additional loss of genetic variability, and mitigating habitat impacts, primarily those caused by the construction and operation of Libby Dam. Therefore, the recovery strategy addressed these concerns through three priority actions: (1) Augment spring and early summer flows of the Kootenai River to enhance natural reproduction; (2) implement a conservation aquaculture program, i.e., artificial propagation and release to prevent extinction; and (3) reestablish suitable habitat conditions to increase the chances of white sturgeon survival beyond the egg or larval stage (USFWS 1996).

In 1990 the conservation aquaculture program started to address experimental questions but was not fully implemented until 1991. In 1991, 1992, 1993, 1995, and 1998, progeny from wild broodstock were successfully produced and reared in the Kootenai Tribal Hatchery, home of the conservation aquaculture program. While efforts to restore natural reproduction, such as augmented discharge during spawning periods, stimulated natural spawning, these efforts did not appear to restore natural recruitment in the population (Paragamian and Kruse 1996). In the short term, propagation, culture, and release of juvenile white sturgeon appeared to be the most viable option for preventing extinction of this species. The program aimed to address several concerns about the use of supplementation regarding genetic variability and the potential introduction of disease into the wild population.

This case study describes how the issue of introduced disease was addressed. The following sections provide a brief description of white sturgeon iridovirus (WSIV), chronicle a white sturgeon virus epizootic that occurred in 1992, describe the disease management implications of WSIV on the conservation aquaculture program and preservation stocking program, and conclude with a look at future research needs. This case study may be useful for developing other supplementation programs intended to benefit endangered species.

White Sturgeon Iridovirus

The original description of white sturgeon iridovirus disease (Hedrick et al. 1990) resulted from observations of hatchery-raised sturgeon. The source of the virus was not determined at that time, but researchers assumed it originated from captive wild white sturgeon adults collected from the Sacramento River (California) for use as broodstock. The virus also has been detected in cultured white sturgeon from the lower Columbia River in Oregon, Snake River in southern Idaho, and Kootenai River in northern Idaho (LaPatra et al. 1994). Based on its ubiquitous distribution and high frequency of occurrence, WSIV is the most prevalent viral pathogen in this species. This agent has an affinity for epithelial tissue of the skin and gills. High mortality may occur (>90%), presumably from anorexia and disruption of normal respiration and osmoregulation. Secondary infections such as external fungal infections are not uncommon in compromised fish, and the disease caused by WSIV is most severe in juvenile sturgeon younger than age 1.

Numerous observations suggest that WSIV is endemic in wild sturgeon populations throughout the

Figure 1 shows the location of the Kootenai River system and the Kootenai Hatchery, where juvenile white sturgeon were propagated for conservation aquaculture.

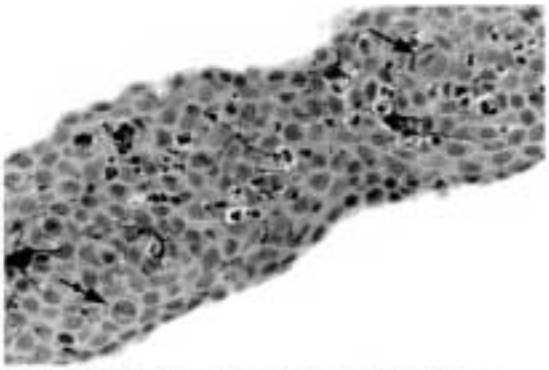

Figure 2. Light photomicrograph of white sturgeon operculum demonstrates that infection of opercular skin cells with WSIV results in cellular hypertrophy (arrows) and increased basophilia of the cytoplasm. Hematoxylin and eosin. x132.

Pacific Northwest (LaPatra et al. 1994), perhaps because of the long life span and highly migratory nature of white sturgeon as well as the continuity of the river systems. Since the disease appears to be related to size (age) and stress, managers have implemented culture management strategies to avoid or minimize WSIV disease. Successful strategies have included fish culture density and loading reduction, use of virus-free water supplies, minimization of adverse environmental conditions, and minimal handling of sturgeon younger than age 1 (LaPatra et al. 1994; LaPatra et al. 1996b).

White Sturgeon Virus Epizootic

During November 1992 increased mortality occurred in 6-month-old juvenile white sturgeon at the Kootenai Hatchery. The mortality was likely due to high fish densities (32–48 kg/m^3) and a temporary loss of water. To decrease the mortality by improving rearing conditions, approximately 800 of the 5,000 affected sturgeon were transferred to an Idaho State Hatchery in Sandpoint.

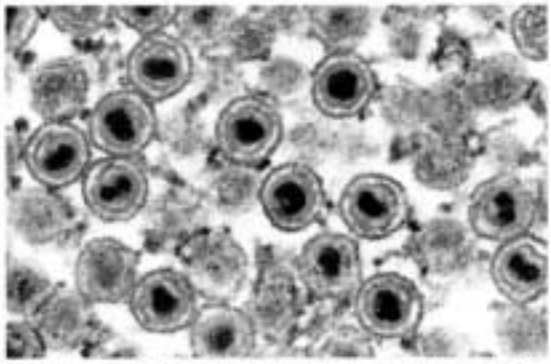

Figure 3. Transmission electron micrograph of white sturgeon gill tissue shows that the infected cells contain multiple iridovirus particles. Lead-citrate and uranyl acetate. x55,000.

Approximately 75% of the 800 fish transferred to the Sandpoint Hatchery died in comparison to 48% of fish that remained at the Kootenai Hatchery. Therefore, mortality rates may have been exacerbated by the stress of transportation. Scientists initiated an investigation to determine the cause of mortality that included histopathological examination of tissues from fish at both hatcheries. This examination revealed lesions in the gills and skin typical of those manifested in WSIV disease (Figure 2). Samples from fish at the Kootenai Hatchery also were examined by transmission electron microscopy, which confirmed the preliminary diagnosis of WSIV (Figure 3). A total of 2,600 of the 5,000 fish died as a result of the epizootic.

A similar epizootic occurred in cultured juvenile sturgeon from southern Idaho. However, reducing densities and increasing water flow decreases the mortality (T. L. Patterson, College of Southern Idaho Aquaculture Program, Twin Falls, pers. comm.). These observations suggested that juvenile white sturgeon infected with WSIV did not exhibit clinical disease until they were subjected to stressful conditions. This has been supported by the absence of mortality in other groups of juvenile white sturgeon originating from the same source and maintained at decreased densities despite decreased water flows at the Kootenai Hatchery. In another example, Sandpoint Hatchery-reared sibling juvenile sturgeon from the fertilized egg stage were not subjected to low water flows and crowded rearing conditions. Despite the apparent presence of WSIV, mortality did not increase. One apparently healthy animal displayed typical WSIV lesions (A. K. Hauck, Utah Department of Agriculture, Salt Lake City, pers. comm.), but scientists did not determine if WSIV was endemic in this group or if the virus was introduced during propagation.

This epizootic represented the first known occurrence of WSIV infection in Kootenai River white sturgeon. Although the source of this virus was not determined, it may have originated from Kootenai River wild sturgeon that were held on site for 2 months and maintained as broodstock. The water did not appear to be a likely source of the virus since, at the time, the culture facilities were using dechlorinated tap water, not Kootenai River water. Kootenai River water may not have been a plausible cause even if it were used in the culture facilities since one group of juvenile sturgeon reared in Kootenai River water did not exhibit mortality due to WSIV.

Kootenai River White Sturgeon Conservation Aquaculture Program

The Kootenai River white sturgeon was listed as an endangered species partially based on the available genetic evidence that the population represented a distinct and unique strain of white sturgeon (Setter and Brannon 1990, 1992). As a condition of the listing, a 10-year conservation program was implemented as part of the USFWS White Sturgeon Recovery Plan (USFWS 1996).

The plan specifically includes the collection of wild adult Kootenai River white sturgeon by rod and reel, and setline each spring. Fish are used as broodstock at the

Kootenai Hatchery for the artificial propagation and captive rearing of juvenile white sturgeon (Figure 4). The conservation aquaculture program strategy outlined in the recovery plan was designed to (1) maintain the genetic variability within the wild population, (2) reduce the risk of disease to the wild spawning population, and (3) reduce selection of artificial characteristics during the selection and mating of broodstock and/or the juvenile sturgeon cultivation (USFWS 1996). A breeding plan, the "Kincaid Plan" (Kincaid 1993), designated that wild adults representing both the temporal and geographic natural spawning run would be collected for use as broodstock. The Kincaid Plan aims to maximize the number of different adults contributing gametes and progeny to the population over time while minimizing the contribution of any one sibling group. Release of juvenile white sturgeon into the natural environment was recommended either as soon as suitable identifiable marks or tags could be applied to the fish or when the fish are no older than age 2 (Figure 5). Since the fish reaches sexual maturity at approximately age 20, natural selection should counteract any potential impact of domestication in the cultivated juvenile white sturgeon.

A concern of professionals involved in the conservation aquaculture program also was the potential for introduction of disease into the native population (USFWS 1996). In response, scientists developed a strategy to prevent or reduce the transmission of disease from cultured fish to the wild population. This included implementing fish culture practices, policies, and procedures developed for the anadromous salmonid hatcheries (Integrated Hatchery Operations Team 1995). A disease-testing protocol was specifically developed for this program. It was implemented prior to the release of any hatchery-reared Kootenai River white sturgeon into the Kootenai River. The plan included virological and bacteriological testing of 30 fish along with examination for parasites in skin and gill wet mounts from 10 fish. Additionally, histological examination of all major organs of 20 fish was required. A qualified fish health professional supervised this disease-testing protocol.

Kootenai River White Sturgeon Preservation Stocking Program

From 1990 to 1993, progeny from wild Kootenai River white sturgeon broodstock were successfully produced and reared at the Kootenai Hatchery. During this period, five females were mated with 10 males, resulting in five families of progeny. Two experimental releases totaling 305 hatchery-reared 1- and 2-year-old fish were released into the Kootenai River in 1992 and 1994. Included in the total were 91 survivors of the 1992 WSIV epizootic. They were tagged, marked by scute removal, and released in three locations on the Kootenai River from July to September 1994 (Siple and Anders 1994). The survivors did not exhibit evidence of a WSIV infection at the time of release, which was consistent with the conservation aquaculture program directives (Bonneville Power Administration 1997). During 1995 and 1996, fisheries professionals used gill nets to capture 70 hatchery-reared white sturgeon

Figure 4. Larval white sturgeon were artificially propagated at the Kootenai Hatchery. These fish were progeny of wild Kootenai River white sturgeon that were captured and used as broodstock in the conservation aquaculture program.

(Paragamian et al. 1995, 1996), indicating that released sturgeon were surviving in the Kootenai River.

In 1995, two wild Kootenai River adult white sturgeon females were mated with four males that resulted in four families or two pairs of half-sibling families, each with a shared female parent. This mating scheme was used to maximize genetic diversity in the progeny fish by maintaining genetically different broodstock. Prior to the 1997 release of the sturgeon (mean age, 2 years), a disease-testing protocol was implemented specifically developed by agreement among the cooperating parties. Although no pathogens were detected, histological examination of the skin revealed a 40% prevalence of cellular changes indicative of WSIV. However, these findings were not associated with morbidity or clinical signs of infection; i.e., infection occurred in the absence of disease (asymptomatic infection). Two of the families did not exhibit signs of WSIV infection or had a low prevalence and intensity of infection.

Figure 5. Juvenile Kootenai River white sturgeon were artificially propagated in the conservation aquaculture program. Release of juvenile white sturgeon into the natural environment occurred when identifiable marks or tags could be applied or when the fish were no older than age 2.

Table 1. Monthly prevalence of WSIV infection was determined by histological examination of skin specimens obtained from two groups of 1995 brood year 2-year-old Kootenai River white sturgeon.

Month (1997)	Water Temperature (range)	Family Number 30	Family Number 33
May	8.7°C (6.3–11.1)	100% (10/10)	100% (10/10)
June	10.6°C (7.2–14.0)	50% (5/10)	20% (2/10)
July	15.1°C (12.8–17.3)	11% (2/19)	10% (2/20)
October	11.3°C (9.8–12.8)	0 (0/10)	20% (2/10)

These families were individually tagged and released as approved by the oversight committee. The rationale for this decision was based on (1) the absence of disease in the infected group and (2) the circumstantial evidence suggesting that WSIV was endemic in the population and had evolved with the wild white sturgeon throughout their range. Furthermore, wild sturgeon used for broodstock were considered the most likely source of WSIV infection in the progeny. In the final analysis, the release of sturgeon infected with WSIV was considered the most prudent strategy in the face of a progressive decline of the Kootenai River white sturgeon population with little improved natural recruitment.

The fish that remained in captivity at the Kootenai Hatchery were composed of two families. These fish were maintained at low densities and monitored monthly for WSIV infection using a nonlethal sampling method. The maintenance of reduced densities was considered the most prudent strategy to minimize infection and prevent disease. An additional prudent strategy was prolonged holding and monitoring of the infected groups as the water temperature increased, thus enhancing the immunological capabilities of the animals.

Figure 6. Juvenile Kootenai River white sturgeon were fitted with a sonic tracking device and, after release, were monitored using sonic tracking and gill netting.

The initial sampling of these two remaining families in May 1997 indicated that 100% of the animals were asymptomatically infected. The intensity of infection was mild. Ten individuals from each family were subsequently tagged and nonlethally sampled at monthly intervals. From May through August, as water temperature progressively increased to 15.6°C, the individual sturgeon that had tested positive for WSIV exhibited no evidence of the virus. Apparently, the prevalence of WSIV decreased to negligible levels without evidence of clinical disease (Table 1). Therefore, all of the remaining sturgeon were tagged and released into the Kootenai River in October 1997. In summary, 2,283 white sturgeon juveniles representing four family groups from the 1995 year class were released (Ireland 1997). Currently, researchers are monitoring the fish using sonic tracking (Figure 6) and gill netting.

Discussion

Conservation aquaculture was identified as a prudent and necessary tool for recovery of endangered Kootenai River white sturgeon. The biological status of the species and the demonstrated uncertainties of other recovery efforts justified the use of conservation aquaculture. Conservation aquaculture programs need to address the potential impacts on the genetic variability, artificial selection, and effects of disease on the native population prior to developing and implementing the program. Management strategies should be based on available scientific information to minimize (1) transmission of disease from cultured fish to native fish and (2) the potential severity of disease in the native population. It is essential that these strategies be flexible and are designed to continually incorporate new scientific information.

One of the primary concerns of any artificial propagation program is the potential introduction and transmission of pathogens in both cultured and native populations. Generally, predictions of potential disease impacts in natural populations have been extrapolated from observations of disease conditions in cultured fish. However, these predictions may not be directly applicable to wild populations since conditions associated with aquaculture (e.g., increased densities, suboptimal water quality) often promote clinical manifestation of infection. High-density conditions that can occur in culture facilities also can promote progressive and relatively rapid disease transmission among captive populations.

Conceptually, infection and disease are separate phenomena, although these events are often mistakenly considered in the same context. Simply put, *infection*—defined as invasion of a host by a pathogenic agent—is a more common event, although both infection and disease depend on the interaction of various factors, including (1) the health and immunological status of the host, (2) the dose and virulence of the pathogen, and (3) the environmental conditions that affect the host and pathogen (LaPatra 1998). In contrast, *disease* is defined as the condition

that results in morbidity and, possibly, mortality in the individual host or population as a consequence of infection.

The extent and severity of disease also is a function of these various factors. Adverse environmental factors include temperature and conditions that may increase stress in fish populations such as inadequate water flows and increased densities. Conditions that promote or exacerbate disease are generally more prevalent and pronounced in aquaculture facilities than in wild populations. Increased densities are not only conducive to disease but also promote the rapid and progressive transmission of infection throughout the population. However, increased incidence and severity of disease in aquaculture for any pathogen is generally due to adaptation of pathogens over time that can become endemic to a species (LaPatra 1997). This is important for viral pathogens that have a restricted host specificity such as WSIV. For example, experimental exposures of WSIV to chinook salmon (*Oncorhynchus tshawytscha*), channel catfish (*Ictalurus punctatus*), and striped bass (*Morone saxatilis*) indicated their resistance to infection, but lake sturgeon (*Acipenser fulvescens*) suffered a mild form of the disease (Hedrick et al. 1992). In wild populations an increased incidence of morbidity and mortality would result in extinction of the host species and its endemic pathogen. Therefore, asymptomatic infection may be widely distributed throughout wild populations without clinical manifestation of disease that may subsequently occur due to aquaculture-specific stressors.

Clinical disease that results in sickness and/or death is more easily diagnosed than asymptomatic infections or subclinical disease that may require more sophisticated diagnostic tests or procedures. Regardless, the isolation or presence of a pathogen does not indicate a disease event. However, identifying a pathogen in otherwise healthy fish populations should be followed by review and appropriate alteration of husbandry and management practices to prevent possible future disease events. Changes in these practices may simply be the alteration or management of specific environmental conditions such as the maintenance of decreased culture densities or increased water flows necessary to minimize or prevent potential future disease events in the population (LaPatra 1997). These preventative measures also may apply to wild populations and are underscored by the recent decline in the Kootenai River white sturgeon population as a result of changes in the physical and biological parameters of the river ecosystem after construction of Libby Dam.

As mentioned, WSIV is the most prevalent viral pathogen of white sturgeon relative to its distribution and frequency of occurrence, and may be endemic to wild white sturgeon populations throughout the Pacific Northwest. The latter assumption is based on observations that wild sturgeon used as broodstock were the source of WSIV in progeny of these broodstock and that clinical manifestation of disease in these progeny was due to adverse environmental conditions (LaPatra et al. 1994; LaPatra et al. 1996). In 1992 juvenile Kootenai River white sturgeon were destroyed, and movement of surviving fish was severely restricted following diagnosis of WSIV in this group of fish. These juvenile fish were invaluable due to the progressive decline in the natural population and the failure to reestablish natural recruitment in the population with augmentation of water flows in the Kootenai River. This response was probably not necessary based on the available scientific information that infection may be a natural phenomenon within the wild population.

Conclusions

Intervention to stabilize the population and the continual adaptation of management strategies to achieve this

Table 2 lists individuals involved in the Kootenai River white sturgeon cooperative effort and their professional affiliations.

Name	Agency	Specialty
Susan Ireland	Kootenai Tribe of Idaho, Bonners Ferry	Fisheries biologist/manager
Scott LaPatra	Clear Springs Foods, Inc., Buhl, Idaho	Fish health specialist
Joseph Groff	University of California, School of Veterinary Medicine, Davis	Fish health specialist/veterinarian
Robert Hallock	USFWS, Spokane, Washington	Fisheries manager
Stephen Duke	USFWS, Boise, Idaho	Recovery team leader
John Morrison	USFWS, Olympia, Washington	Fish health specialist
Kathy Clemens	USFWS, Ahsahka, Idaho	Fish health specialist
Larry Lockard	USFWS, Kalispell, Montana	Fisheries biologist
Jay Hammond	BC Ministry of Environment, Land, and Parks, Nelson	Fisheries manager
Sally Goldes	BC Ministry of Environment, Land, and Parks, Nanaimo	Fish health specialist
Gordon Ennis	CDFO, Vancouver, British Columbia	Fisheries manager
Dorothy Keiser	CDFO, Nanaimo, British Columbia	Fish health specialist
Ned Horner	Idaho Department of Fish and Game, Coeur d'Alene	Regional fisheries manager
Keith Johnson	Idaho Department of Fish and Game, Eagle	Fish health specialist
Vaughn Paragamian	Idaho Department of Fish and Game, Coeur d'Alene	Fisheries research biologist
Jim Peterson	Montana Fish, Wildlife and Parks, Helena	Fish health specialist
Brian Marotz	Montana Fish, Wildlife and Parks, Kalispell	Fisheries research biologist
Paul Anders	University of Idaho, Aquaculture Research Institute, Moscow	Fisheries research biologist
Rick Westerhof	National Marine Fisheries Service; formerly of Bonneville Power Administration, Portland, Oregon	Fisheries biologist
Scott Bettin	Bonneville Power Administration, Portland, Oregon	Fisheries biologist
Jeff Laufle	U.S. Army Corps of Engineers, Seattle, Washington	Fisheries biologist

USFWS = U.S. Fish and Wildlife Service
CDFO = Canada Department of Fisheries and Oceans

objective were partially the result of the uncertain status of the wild Kootenai River white sturgeon population. However, development of management strategies also was influenced by relevant scientific information that became available during implementation of the Kootenai River white sturgeon conservation aquaculture program. This case study illustrates the importance of conservation aquaculture programs in certain situations and the necessity that management strategies remain flexible and adapt to the current available scientific information for maximum benefits. Fisheries professionals are continuing efforts to understand the ecology and natural history of WSIV in white sturgeon to ensure the best possible management of the species. Successful development and use of nonlethal sampling procedures for detecting WSIV infection will permit the future examination of tagged fish released from the Kootenai Hatchery and wild-caught sturgeon broodstock. Hatchery renovations also have begun to minimize the adverse conditions associated with artificial rearing and to prevent or minimize infectious disease. Finally, surveillance strategies that are more sensitive and specific to detection of these pathogens need to be developed and used in conservation aquaculture programs and management of the population.

Restoration of an entire population that has been severely altered for decades and that inhabits a large floodplain ecosystem such as the Kootenai River system requires long-term, multiagency cooperation and commitment. Management of the Kootenai River white sturgeon population represents a model cooperative effort of professional fisheries scientists of various disciplines from private industry; academia; Native American tribes; and provincial, state, and federal agencies (Table 2). This cooperation is a necessary prerequisite for the successful achievement of the program goals and continual modification and adaptation of management strategies. Furthermore, such a cooperative effort illustrates that effective management of entire populations is best achieved through interdisciplinary cooperation of various fisheries professionals. This interdisciplinary cooperation reflects a current trend in the fisheries profession that replaces the more traditional approach of various professionals working in isolation on separate aspects of the same problem. Obviously, the latter approach is less effective and, therefore, less desirable for managing threatened or endangered populations such as the Kootenai River white sturgeon.

Acknowledgments

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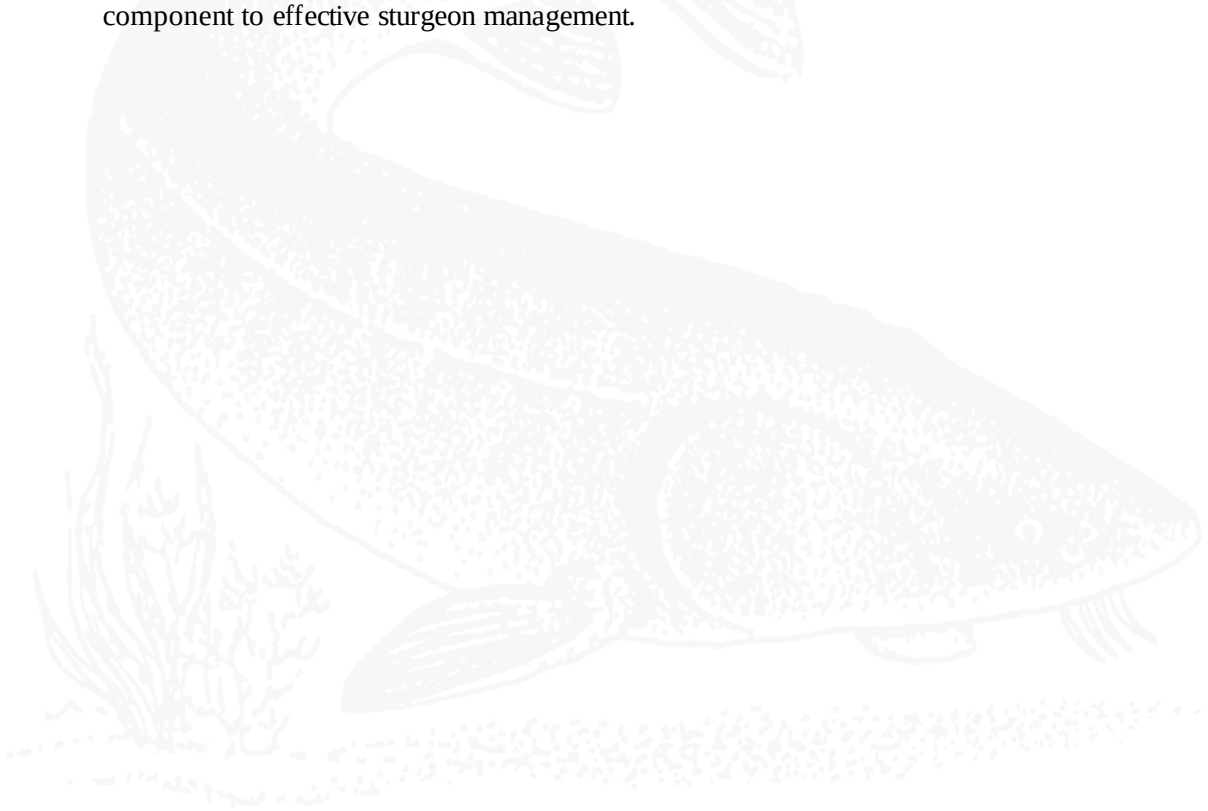
Management of lake sturgeon on the Winnebago System – long term impacts of harvest and regulations on populations structure

Summary

The Winnebago System, Wisconsin, supports one of the largest self sustaining stocks of lake sturgeon, Acipenser fulvescens, in North America. Winter spearing harvest of the Winnebago sturgeon population has been actively regulated since 1903 and actively assessed sicken the 1940's. While historic population assessments have shown a steady increase in sturgeon densities in the system, recent surveys indicated overexploitation of adult females. From 1991-97, 13,714 sturgeon were assessed through harvest and spawning surveys to characterize the status of the current population, and historical data from DNR files were reassembled and analyzed to discern population trends over the last 40 years. A summary of management actions since 1903 was completed and reviewed in the context of long term population trends. 1991-97 annual harvests averaged 1337 sturgeon with adult females comprising 46% of the annual harvests from 1991-96 and 34% of the harvest in 1997 following a reduction in the minimum size limit. With the higher size limit, estimated annual exploitation of adult females was 2 to 3 times higher than that of adult males. Historic harvest and population trends showed the benefits of conservative bag limits and harvest season lengths combined with strict law enforcement, and habitat protection, which resulted in an estimated 58% reduction in the annual harvest between 1955 to 1990. The analyses of the historic data reinforced the necessity of standardized long-term harvest and population assessments for effective management of sturgeon populations and fisheries. Public involvement is also identified as an integral component to effective sturgeon management.



Management of lake sturgeon on the Winnebago System - long term impacts of harvest and regulations on population structure

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Summary

The Winnebago System, Wisconsin, supports one of the largest self sustaining stocks of lake sturgeon, Acipenser fulvescens, in North America. Winter spearing harvest of the Winnebago sturgeon population has been actively regulated since 1903 and actively assessed since the 1940's. While historic population assessments have shown a steady increase in sturgeon densities in the system, recent surveys indicated overexploitation of adult females. From 1991-97, 13714 sturgeon were assessed through harvest and spawning surveys to characterize the status of the current population, and historical data from DNR files were reassembled and analyzed to discern population trends over the last 40 years. A summary of management actions since 1903 was completed and reviewed in the context of long term population trends. 1991-97 annual harvests averaged 1337 sturgeon with adult females comprising 46% of the annual harvests from 1991-96 and 34% of the harvest in 1997 following a reduction in the minimum size limit. With the higher size limit, estimated annual exploitation of adult females was 2 to 3 times higher than that of adult males. Historic harvest and population trends showed the benefits of conservative bag limits and harvest season lengths combined with strict law enforcement, and habitat protection, which resulted in an estimated 58% reduction in the annual harvest between 1955 and 1965 and a four fold increase in legal stock densities from 1955 to 1990. The analyses of the historic data reinforced the necessity of standardized long term harvest and population assessments for effective management of sturgeon populations and fisheries. Public involvement is also identified as an integral component to effective sturgeon management.

Key words: Lake sturgeon, Acipenser fulvescens, management, regulations, public involvement.

Introduction

The Lake Winnebago System, in east central Wisconsin, is home to one of the largest self sustaining stocks of lake sturgeon, Acipenser fulvescens Rafinesque, in North America. The population supports a popular recreational spear fishery each winter and has been subject to hook and line, and setline fisheries in the past. The fishery has been regulated since 1903 and the sturgeon population and harvest have been consistently monitored and managed since the early 1940's (Schneberger and Woodbury 1946), (Probst and Cooper 1954), (Priegel and Wirth 1975, 1978), (Folz and Meyers 1985). Studies conducted over the years have been primarily concerned with ensuring that exploitation was maintained at a safe level. Information was used to increase the understanding of the population dynamics of the Winnebago system lake sturgeon to identify possible limiting factors and to make necessary adjustments in harvest seasons and bag and size limits.

Since the early 1950's various studies have documented an increase in Winnebago sturgeon stocks from 11500 (>102 cm) in 1959 (Priegel and Wirth 1975) to 25300 (>114 cm) in 1980 (Folz and Meyers 1985) and to 46500 (>114 cm) in 1989 (L.S. Meyers, Wisconsin Department of Natural Resources (DNR), personal communication). Harvest trends though, began to show a steady decline in the relative number of trophy size (>45.4 kg) sturgeon speared each year since the early 1970's. Trophy size sturgeon comprised 1.9% of the harvest between 1955 and 1969, falling through the 1970's and early 1980's to 1.3%, and precipitously over the last 13 years to 0.3% of the harvest. Information from various population assessments conducted in the 1950's, 1970's and 1980's also showed a decline in the relative number of larger, older fish. As the largest fish in the population are typically mature females, interest and concern led to an expansion of population and harvest assessments beginning in 1991 along with a complete evaluation of the long term impacts of harvest regulation changes on the lake sturgeon population structure.

Study Objectives

1) To summarize the history of Winnebago System lake sturgeon regulatory and management actions,

2) To characterize the current (1991-97) Winnebago System lake sturgeon population and fishery,

3) To examine historical population and harvest assessment data for trends that may have been the result of various regulatory, anthropogenic, and/or environmental factors, that may have led to characteristics of the current population.

Study Area

The Winnebago System is a large, eutrophic riverine-lake system in east central Wisconsin Figure 1). Lake Winnebago and the three Upriver Lakes (Butte des Morts, Winneconne and Poygan), collectively known as the Winnebago Pool Lakes, comprise 66845 ha of surface water, situated at the lower end of a 1554026 ha watershed through which flow the Wolf and upper Fox River Systems. The lower 200 km of the Wolf River, along with its major tributaries, and 60 km of the upper Fox River contain the spawning and nursery grounds for the Winnebago Pool sturgeon population. Lake Winnebago has a maximum depth of 6.4 m and a mean depth of 4.7 m. The Upriver Lakes are also relatively shallow with a maximum depth of 5.4 m and a mean depth of 1.8 m. The Winnebago Pool Lakes have a methyl orange alkalinity of 119 to 124 ppm, a pH varying from 7.7 to 8.5., and are characterized by large, open pelagic areas with a soft sediment base and by poor water clarity due to a lack of aquatic macrophytes, nonpoint pollution, resuspension of sediments from wave action and algal blooms. In addition to lake sturgeon, the major species of the

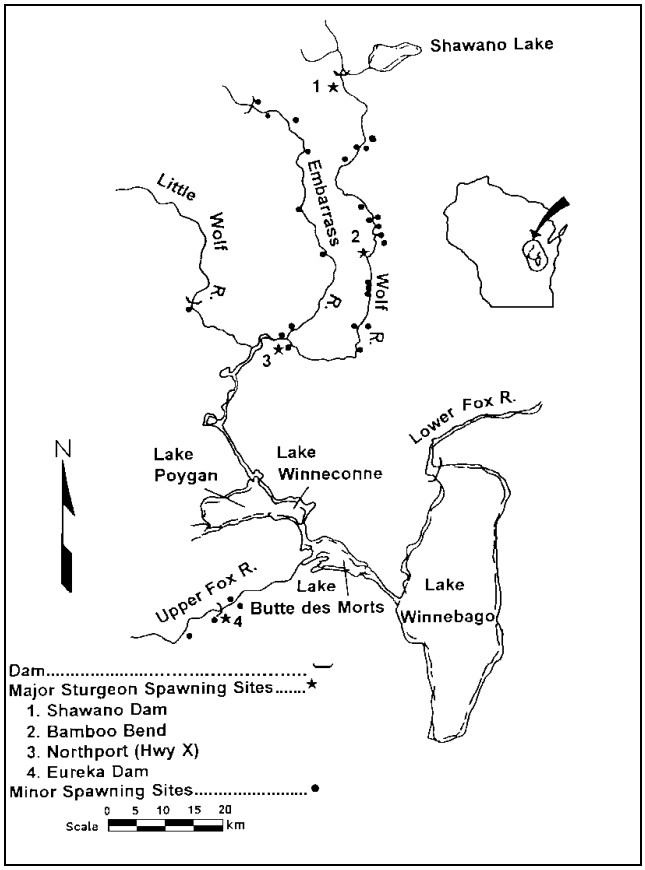

Fig. 1: Winnebago System, with lake sturgeon spawning sites.

Winnebago Pool fisheries community include freshwater drum, walleye, sauger, yellow perch, white bass, trout perch and emerald shiner. Seventy-eight species of fish have been reported from the Winnebago Pool Lakes. The Winnebago system lies within 120 km of two million people and receives heavy use from recreational boaters and anglers (WDNR, Winnebago Comprehensive Management Plan, 1989).

Methods

Historical Review of Winnebago System Lake Sturgeon Regulatory and Management Actions

Historic information on regulatory and management actions initiated to control the Winnebago System lake sturgeon fisheries was found primarily in files housed at the Wisconsin Department of Natural Resources (DNR) Oshkosh Service Center. Information was thoroughly reviewed and discussed, where possible, with individuals who initiated or participated in the various actions.

Characterization of the Current (1991-97) Winnebago System Lake Sturgeon Population and Fishery

The current Winnebago System lake sturgeon population and fishery was examined through harvest and population assessments conducted from 1991-97. The 1991-97 assessments were designed to provide data comparable to historic assessments and to also provide estimated densities and age structure of males and females in the spawning stock and the sex and maturity of harvested fish. Previous assessments conducted since the early 1950's, have provided relatively consistent data on estimated densities of the stock of legal sized fish, the size structure of the spawning stock, and spearing harvest - numbers harvested and effort, size and age distribution of harvested fish and estimated exploitation rates.

Historically, density estimates were derived for all legal size sturgeon in Lake Winnebago. In certain years, sturgeon (unsexed) captured in DNR "sheepshead", Aplodinotus grunniens, removal trawling operations, were tagged and released, and recapture data were collected the following winter in the spear fishery. After these operations ceased in 1990, sturgeon tagged in the spring on the Wolf and upper Fox Rivers during their spawning period were used as the marked portion of the population for deriving density estimates, with the recapture data collected the following winter during the spear fishery. Therefore density estimates attempted after 1990 were for adult males and females in the spawning stock only.

Density estimates were derived using Chapman's modification of the Petersen estimate according to Ricker (1975), with an adjustment to account for spawning migration patterns.

During the spawning periods of 1991-97, sturgeon were captured at upriver spawning sites on the Wolf and upper Fox River using handheld dip nets as the fish spawned along current swept, rocky, river shorelines. All captured fish were measured in total length to the nearest half inch, sexed, tagged with a monel metal tag (size 49) and released. All males were sampled for age in 1992 and 1993 and all females were sampled for age in 1992-95.

Harvest data were collected at registration stations as successful spearers brought in their fish. During the 1991-95 spearing seasons, fish were registered by local taverns and restaurants, with DNR fisheries staff sampling fish at stations every Saturday, Sunday, Wednesday, Thursday and Friday of the season. Beginning in 1996, DNR fisheries staff assumed responsibility for all registration operations which allowed every fish registered to be examined. In each year of the study all fish examined by DNR staff were measured in total length to the nearest one half inch, and weighed to the nearest half pound, checked for tag returns, and sexed and staged. The sex and stage of maturation of harvested fish was determined using techniques and criteria developed by Bruch, Dick and Choudhury (1997, in press). In the 1991-94 seasons all fish examined were sampled for age by removing the anterior ray of a pectoral fin. In 1995 and 1996, fish were randomly subsampled by sex for age.

All fin bones were cross sectioned using an Isomet Low Speed Saw and examined under a binocular scope to determine the number of annuli present.

Harvest effort was estimated via aerial counts of spearing shanties on the ice on the opening day of each spearing season.

Minimal exploitation rates of the mature spawning stock were developed from tag recapture data from marks applied in the spring tagging efforts in 1991-96, and recovered in the subsequent winter spear fishery. Dorsal fin scarring data collected during spring assessments were used to develop a one year tag retention rate, which in turn was used to adjust the expected number of marks available in the harvestable population.

Total annual mortality rates (A) were derived from catch curves according to Ricker (1975).

Historical Population and Harvest Assessment Data Review and Analysis

All historic data from harvest and spawning assessments conducted between 1941 and 1990 were also gathered from data files housed at the DNR Oshkosh Service Center. Data were tabulated and analyzed to discern long term trends and changes in population size and age structure. No data exist on any set line or hook and line harvests.

Historic trends on the following parameters were examined: estimated population densities, size distribution of males and females in the spawning stock, annual harvest and harvest effort, minimal exploitation rates, size and age distribution and condition of harvested fish and total annual mortality rates.

Density estimates for the Winnebago harvestable lake sturgeon stock were calculated over the years by various researchers - Priegel and Wirth (1975) for the period 1955-59, Folz and Meyers (1985) for the period 1976-83, and Meyers for 1990 (DNR, personal communication).

Size distributions of males and females in the spawning stock were determined using total length data collected during spring spawning assessments for the years 1954-64, and 1975-90.

Annual spear harvests from 1941-54 were estimated via creel surveys, except for 1943-45 when no censuses were conducted. Since 1955, mandatory registration has provided records of annual harvests.

Harvest effort has been measured on Lake Winnebago since 1956, and on the Upriver Lakes since 1952 via ice shanty counts taken from the air on the first day of the spearing season. Spearing license sales data also exist since the inception of the license in 1960, but were not used as a measure of effort due to substantial inconsistencies in license sales distribution and use patterns.

Estimated historic exploitation rates of adult sturgeon were developed from tagging studies conducted during spawning periods from 1954-64 and 1975-90, with recapture data collected in subsequent winter spear fisheries.

Size distributions of harvested fish were calculated using total length and weight data collected from harvested fish. Age distributions were calculated from age data collected during the harvest assessments in 1953-1969, 1975-76, 1981 and 1986.

Condition factors were calculated according to Carlander (1969) using the formula:

$$K' = (10^5 * W)/L^b$$

where:

W = weight
L = total length
b = slope of the LogW on LogL regression.

Total annual mortality rates were calculated as described earlier.

All historical data were reviewed in the context of regulatory changes and unusual environmental conditions to determine coincidences and/or relationships between events and population parameters.

Results

Summary of Winnebago System Lake Sturgeon Regulatory and Management Actions

The sturgeon fishery of the Winnebago System appears to have always been maintained through natural reproduction. No records were found to indicate sturgeon have ever been stocked into the system. Sturgeon have been regularly harvested from the Winnebago System waters via spearing, hook and line, as well as other methods since pre-European settlement (Probst & Cooper 1954). Harvest regulation began in 1903 with the enactment of a statewide minimum size limit for lake sturgeon of 8 lbs (3.6 kg), with no bag limit on the number of fish an individual could harvest. All sturgeon harvest on the Winnebago System was banned from 1915 through 1931. While no records were found explaining the specific justification for the closure, it can be safely assumed the closure was enacted out of concern for preserving the sturgeon stock. The initial "modern day" spearing season for sturgeon on Lake Winnebago took place in the winter of 1931-32. Setline, as well as hook and line seasons, were also established for certain time periods on parts of the Winnebago System, but neither have been legal since the 1950's. The first spearing season on the Upriver Lakes took place in 1952 as an annual season to replace the abolished setline fishery. At the time, the Upriver Lakes sturgeon population was considered to be separate from the Lake Winnebago population (Priegel and Wirth 1978) and was managed as thus.

Over the years, the lengths of the Lake Winnebago and Upriver Lakes spearing seasons and seasonal bag limits have been reduced several times, and the minimum size limit was increased twice in efforts to control harvest and maintain average annual exploitation at or below 5% (Priegel and Wirth 1975). The minimum size limit was increased also as a means to protect young fish to allow them to reach the size of sexual maturity before entering the legal stock. Recommendations to increase the minimum size limit over the years were based on the assumption that harvests would be reduced proportional to the percentage of fish, for example, under 102 cm from a harvest with a 76 cm size limit, and reduced even further if the minimum size limit would be increased to 114 cm. In other words, it was felt that if 20% of the fish from a harvest with a 76 cm minimum size limit were less than 102 cm, raising the size limit to 102 cm would reduce the harvest by 20% (R. Probst, DNR, personal communication), (Priegel and Wirth 1975).

Numerous fisheries biologists and conservation wardens have worked on the lake sturgeon of the Winnebago System since the early 1940's with some level of work occurring regularly to this day. As different biologists came and went, various and sometimes differing aspects of sturgeon management were emphasized by each. The public, especially the spearing public, has always been interested in the sturgeon regulation and management programs and has become increasingly involved in providing input into management decisions.

The chronology of Winnebago System sturgeon regulatory and management actions is listed in Table 1.

Table 1.
Sturgeon regulatory changes and significant management actions on the Winnebago System from 1903 to 1997.

Pre 1903	No Regulations.
1903	8 lb (3.6 kg) minimum size limit.
1913	14 May to 31 April open season, 20 lb round weight minimum size limit.
1915	All sturgeon harvest on the Winnebago System is prohibited.
1931	First regulated spearing season on Lake Winnebago, open throughout the winter, 30 " (76.2 cm) minimum size limit, 5 bag limit per person per season, tags $.05 each, fishing license required.
1932	Set line fishery opened on the Upriver Lakes, September 5 to October 31, 30" (76.2 cm) size limit, 5 bag limit per person per season (spear and set line fisheries combined), tags $.05 each, set line license required.
1935	Wolf River hook and line season opened (Waupaca and Winnebago Counties), September 5 to October 31, no minimum size limit, 5 bag limit per person per season (spear, set line and hook & line combined), tags $.05 each, fishing license required.
1937	Wolf River hook and line season expanded to include Shawano County.
1939	Hook and line season on Wolf River shortened by two weeks, September 5 to October 15
1940	Hook and line 30" (76.2 cm) minimum size limit initiated, and bag limit modified to allow only 1 fish per day. (maintaining 5 per season limit),
1941	Hook and line season closed on Wolf River. First spear harvest creel census on Lake Winnebago. Lake Winnebago spearing season reduced to one month, February 1 through March 1.
1942	First significant biological assessment conducted on the sturgeon population and spearing harvest.
1944	Hook and Line season reopened on Wolf River but in Winnebago County only.
1946	Hook and line season opened on all portions of Wolf River (now including Outagamie County), retaining previous season length of September 5 to October 15, 30" (76.2 cm) size limit, bag limit of 5 per season, and $.05 tags.
1950	Hook and line, and spearing sturgeon tag fees increased to $1.00 each.
1952	Set line season on Upriver Lakes closed. "Experimental" spearing season conducted on the Upriver Lakes, 16 days February 15 through March 1, 30" (76.2 cm) minimum size limit, seasonal bag limit of three, $.05 tags (Lake Winnebago retained the Feb 1 -March 1 season and the bag limit of 5).
1953	Hook and line seasonal bag limit on Wolf River reduced to 3. Upriver Lakes spearing season reduced to 14 days .
1954	Spearing seasonal bag limit on Lake Winnebago reduced to 3. First biological assessment conducted on the sturgeon spawning stock (conducted annually until 1964).
1955	Minimum size limit for spear fishery (Lake Winnebago and Upriver Lakes) increased to 40" (101.6 cm). Mandatory registration of all sturgeon harvested in spear fishery (Lake Winnebago and Upriver Lakes); fish must be registered on same day speared by 6:00 pm.
1956	Spearing, and hook and line seasonal bag limit reduced to 2 fish. Upriver Lakes spearing season reduced to 9 days. Lake Winnebago spearing season reduced to 2nd Saturday in February through March 1.
1957	Spearing seasonal bag limit on the Upriver Lakes reduced to 1 fish (2 fish limit retained on Lake Winnebago). Upriver Lakes season length reduced to 5 days.
1958	Spearing seasonal bag limit on Lake Winnebago reduced to 1 fish . Spear fishery closed on Upriver Lakes.
1959	Upriver Lakes spearing season reopened for one year for three days (On both Lake Winnebago and the Upriver Lakes at this point there was a 40" (101.6 cm) minimum size limit and a seasonal bag limit of 1). Hook and Line season on the Wolf River closed.
1960	Separate sturgeon spearing license is required at a cost of $2.50; only persons age 14 and over could buy a spearing license, and persons age 16 and over were also required to possess a fishing license; a license could be purchased before, or at anytime during the spearing season.
1962	Upriver Lakes new spearing season format implemented: 2 day season once every three years.
1968	All transported sturgeon must be "openly exposed", i.e they must visible in the transporting vehicle, to a person in a passing vehicle.

1971 Upriver Lakes spearing season format reconfigured again to a 2 day season once every five years.

1974 Minimum size limit increased to 45" (114.3 cm).

1975 Annual spawning stock assessments re-established.

1977 Sturgeon for Tomorrow, a private sturgeon conservation organization, formed by local sturgeon spearers to provide financial and political support for sturgeon aquaculture and other management activities.

"Sturgeon Patrol" initiated in the spring using volunteers (citizens, students, DNR staff, etc) to guard sturgeon spawning sites on the Wolf River 24 hours a day during the spawning period; funded by Sturgeon for Tomorrow.

1980 Spearing license fee increased to $5.50; license has to be purchased prior to season.

1985 $1,500 minimum fine established for possession of illegal sturgeon.

1986 Sturgeon registration hours extended to 7:00 pm during the spearing season.

1991 Expanded harvest and population assessments initiated on Lake Winnebago, the Upriver Lakes and the Wolf and upper Fox Rivers.

1992 Winnebago Citizens Sturgeon Advisory Committee, comprised of representatives of 30 sturgeon spearing and conservation organizations from the Winnebago region, established to work with DNR fisheries and law enforcement staff in the development and implementation of regulations and management actions.

1993 Angling through a sturgeon spearing ice hole prohibited (due to serious illegal hooking problems during the 1992 spearing season).

1996 Emergency rule reduces Lake Winnebago spearing season to nine days with the possibility of extension if the average water clarity on the 3rd day of the season is less than 10 feet (Average water clarity was >12 ft, therefore the season ran only nine days).

1997 Series of new rules went into effect as the 1st phase of the developing Safe Harvest Management System for Winnebago sturgeon:

The Lake Winnebago spearing season length is reduced to 16 days, beginning the second Saturday in February (no change in the Upriver Lakes season format);

The minimum size limit is reduced to 36" (91.4 cm);

Successful spearers are required to accompany their fish to a registration station, and to stay within a specific road boundary around the lake until their fish is registered;

The covering of large ice holes (spearing holes) with shanties is prohibited during periods other than 48 hours before and continuing through the open spearing season;

Hours of sturgeon spear harvest registration are reduced by one hour to close at 6:00 pm.

Status of the Current (1991-97) Winnebago System Lake Sturgeon Population and Fishery

To assess the status of the 1991-97 Winnebago System lake sturgeon population and spear fishery 13,714 sturgeon were captured and/or handled through various assessments (Table 2).

Table 2
Number of lake sturgeon sampled for size, sex and age, 1991-97.

Year	Survey Type	Number sampled for size	Number sampled for sex	Number sampled for age
1991	Harvest	806	245	233
1991	Spawning	200	200	0
1992	Harvest	525	247	247
1992	Spawning	426	426	131
1993	Harvest	1643	428	428
1993	Spawning	442	442	372
1994	Harvest	700	374	374
1994	Spawning	720	720	96
1995	Harvest	3173	1225	622
1995	Spawning	1401	1401	120
1996	Harvest	1221	1198	912
1996	Spawning	819	819	0
1997	Harvest	1290	1288	292
1997	spawning	348	348	0
TOTAL		13714	9361	3827

Population Characteristics, 1991-97

Estimated Densities of Adult Stock

The 1995 lake sturgeon population within the Winnebago System was estimated at 43841 adult males (26867 to 87682 95%CI), 7850 adult females (4194 to 24979 95% CI) and an unknown number of juvenile fish. In attempting to collect the necessary data to develop density estimates for the adult sturgeon stock in the Winnebago System, a number of difficulties were encountered during the study: 1) marking an adequate number of females during the spring spawning run; 2) unreported recaptures during the 1991-1995 spearing seasons; and 3) discovering, during the 1996 Upriver lakes season, that all the fish marked in the spring may not make it back to Lake Winnebago by the February spearing season. Tag return data showed that in some years adult fish remain in the Upriver Lakes on their post spawn migration back towards Lake Winnebago, especially if there is a good food supply such as the high gizzard shad populations during the winters of 1990-91 and 1995-96, which the sturgeon foraged heavily on. Measures were taken to address these difficulties - increasing marking effort in the spring, having fisheries staff register all harvested fish to ensure tag

recaptures are noted, and realizing the best and maybe the only reliable estimates may come from the years with an Upriver Lakes season.

Size and Age Structure, Mean Length at Age of Adult Males and Females

The mean total lengths of adult males and females captured in spawning assessments from 1991-97 were 137 cm and 159 cm, respectively. Mean age in the spawning stock was 21 for males with a range of 12 to 44 years. Mean age of adult females was 29 with a range of 20 to 59 years.

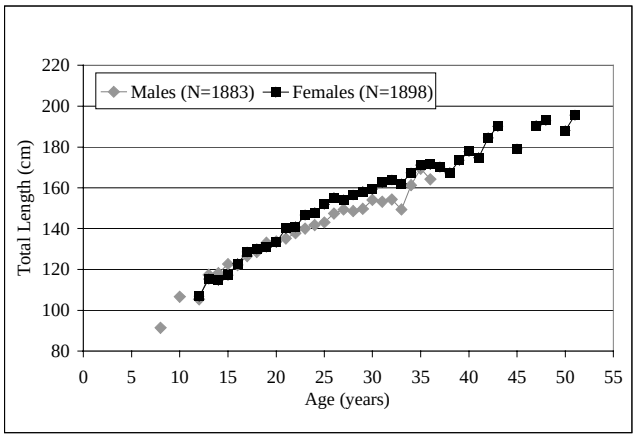

Fig. 2: Lake sturgeon mean total length at age, Winnebago System 1991-97.

Mean length at age of each sex (mature and immature stock combined) shows males and females exhibiting similar growth rates up to age 20, after which the growth rate of males decreases (Figure 2). Males apparently have a substantially shorter life span with very few fish reaching 40 years of age. While females from the Winnebago System have been found to reach an age of 80+ years (D.J. Folz, DNR, personal communication), during the course of the current study, few were found in excess of age 50.

Mortality Rates of Adult Stock

Estimated total annual mortality rates of the adult stock were 16.7% for males age 17 to 28, and 17.3% for females age 26 to 36. Out of 407 males from the spawning stock sampled for age, only 4 were older than age 30. Out of 312 adult females sampled for age, only 11 were older than age 40.

Characteristics of the Spear Fishery, 1991-97

Harvest and Effort

Total harvests for each year, 1991-97 are listed in Table 2. Annual harvests averaged 1337 fish (25725 kg) with a total for the period 1991-97 of 9358 (180078 kg). The 1995 harvest of 3,173 fish was the highest since mandatory registration began in 1955 (Figure 8). Spearing effort on Lake Winnebago ranged from 2238 shanties in 1992 to a record number of 3779 in 1997 (Figure 9). Lake Winnebago shanty counts for the remaining study years were: 1991 - 3131; 1993 - 3615; 1994 - 3400; 1995 - 3760; and 1996 - 3708. Opening day ice shanty counts for the two Upriver Lakes spearing seasons held in 1991 and 1996 were 629 and 1656, respectively. The 1656 shanty count of 1996 was surpassed only once in the history of the Upriver Lakes spear fishery with a count of 1,789 in 1986.

Estimated Minimal Exploitation of Adult Stock

Estimated minimal exploitation through the 1992-97 period averaged 3.2% for adult male sturgeon and 6.0% for adult female sturgeon for the period 1993-97. Tag retention rates were 0.912 for males and .800 for females. Based on observations each spring of the condition of tags on previously marked fish it was felt that most of the tag loss occurs within the first year, after which the tags become "in-grown" on the dorsal fin. Tag retention was highest in fish in which tags were inserted well into the fleshy area at the base of the dorsal.

Low numbers of females tagged in 1991 prevented an exploitation estimate to be calculated for adult females using the 1992 harvest data. Rates for both sexes were obviously higher in high harvest seasons. Exploitation was lower for both sexes, especially for adult females, in 1996 and 1997. Estimated exploitation rates for adult males during the 1996 and 1997 seasons were 1.8% and 1.7%, while the rates for adult females in the same seasons were 5.1% and 5.3%. The rates developed prior to 1996 were likely underestimates due to registration stations missing tags on harvested fish, despite a $10.00 reward offered by Sturgeon for Tomorrow. Following the 1991-95 harvest assessments, when local tavern and restaurant owners were responsible for registering fish, and fisheries staff subsampled the harvested fish at stations for sex and age, a number of tags returns would be sent in to the DNR office, sometimes months after the harvest. These tags had been missed by the registration stations. A comparison of the 1995 daily tag return rates for DNR staffed vs unstaffed stations revealed that, indeed, stations registering fish without DNR staff present missed an average of 14.4% of the tag returns. Therefore, rates developed from tag return data from the 1996 and 1997 seasons would be the most accurate, as DNR fisheries staff registered all harvested fish in those years.

Sex Ratios of 1991-97 Harvests

Male sturgeon comprised an average of 38% of the harvests from 1991-96 and were primarily adult fish (Figure 3). Both adult females (> 140 cm) and juvenile females made up substantial portions of the harvests from 1991-96, comprising 46% and 16%, respectively. In 1997 the proportion of adult females in the harvest dropped to 34% with juvenile females comprising 25% and males

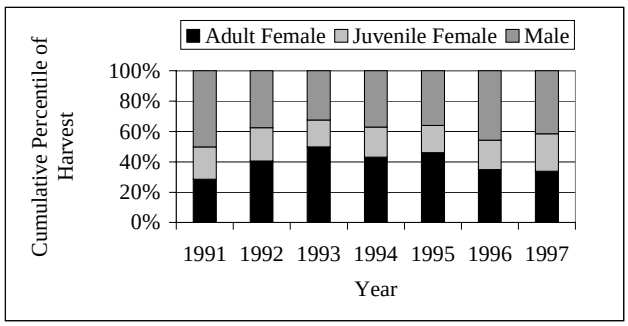

Fig. 3: Lake sturgeon sex ratios, Winnebago System spear harvest 1991-97.

comprising 42%. Overall harvest sex ratios in 1991 and 1996 were more balanced males to females as more males were harvested in the Upriver Lakes fisheries than in the Lake Winnebago fisheries.

The average sex ratio for the 1991 and 1996 Upriver Lakes seasons was 54.3% male and 45.7% female, while the average sex ratio for the 1991-97 Lake Winnebago harvests was 38.5% male and 61.5% female.

Maturity data from the 1991-97 Lake Winnebago harvests revealed that most of the males with fully developed testes (M2 stage) and nearly all of the females with fully developed ovaries (F4 stage) migrate out of Lake Winnebago prior to the spearing season. This pre-spawn movement begins in the fall with fish moving out of Lake Winnebago through the Upriver Lakes and into the Wolf and upper Fox Rivers to stage in deep holes (3 to 9 m) for the winter (D.J. Folz, DNR, personal communication). Maturity data from the Upriver Lakes harvests of 1991 and 1996 revealed that a substantial portion of these fish remained in the Upriver Lakes during those winters feeding on an unusual abundance of gizzard shad. In the 1991 and 1996 Upriver Lakes harvests an average of 60.2% of all males were stage M2, and 33.5% of all females were F4 stage. Of all fish examined from the 1991-97 Lake Winnebago harvests an average of only 12.9% of all males were stage M2 and 2.3% of all females were stage F4.

Size and Age Distribution of Harvested Fish

The mean size of males in the harvest was 135 cm and 15.6 kg from 1991-96, and 133 cm and 13.4 kg in 1997. Females averaged 148 cm and 22.3 kg in 1991-96, and 142 cm and 18.3 kg in the 1997 harvest. Figure 4 illustrates the length frequency distribution of males and females harvested from 1991-96. Analysis of variance

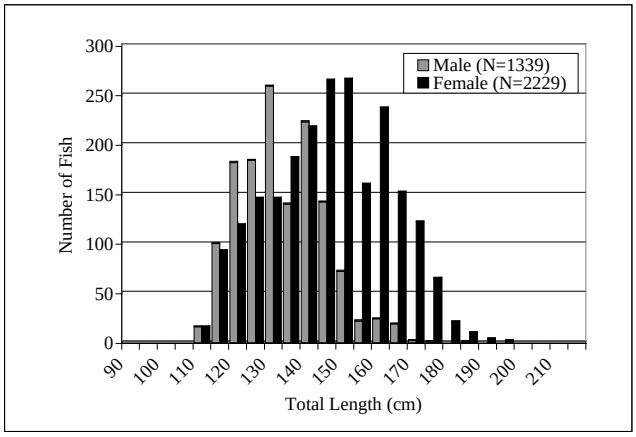

Fig. 4: Lake sturgeon total length frequency, Winnebago System spear harvest 1991-96.

and subsequent least significant difference pairwise comparisons of means found the mean lengths and weights of both males and females harvested in 1997 were significantly less (.05) than those of males and females harvested during the previous six seasons. Males harvested from 1991-96 had a mean age of 21 years, ranging from 10 to 39 years, while harvested females had a mean age of 25 years, ranging from 12 to 51 years.

Historic Population and Harvest Trends

Sturgeon Population Characteristics, 1954-90

Estimated Densities of Legal Sized Stock

Figure 5 illustrates estimated changes in densities of legal stock (all fish larger than 102 or 114 cm) from 1956 through 1990, and the estimated size of the adult stock in 1995. Estimates throughout the 35 year period indicate at least a fourfold increase in densities of legal fish.

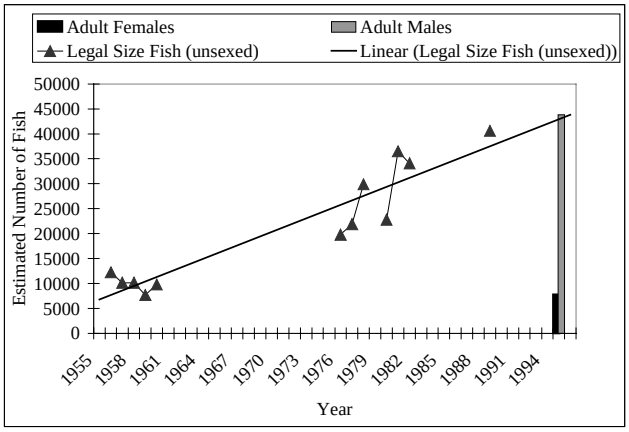

Fig. 5: Lake sturgeon estimated population densities, Winnebago System 1956-95.

Size Structure of the Spawning Stock

Mean total length of males and females in the spawning stock has changed substantially over the last 40 years. Adult males were found to average 137 cm in total length in 1954-64, 132 in 1975-84, 135 in 1985-94, and 138 in 1995-97 (Figure 6). Adult females were

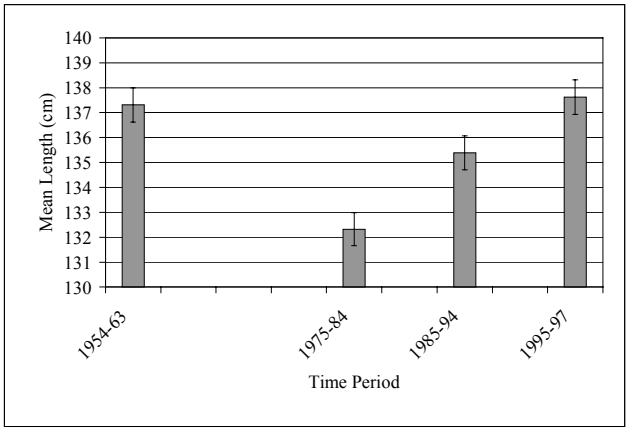

Fig. 6: Adult male lake sturgeon mean total length. Winnebago System 1954-97.

found to average 164 cm in 1954-63, and 160 cm in all periods 1975-97 (Figure 7). Both sexes exhibited a relatively large mean total length in the mid 1950's when spawning assessments first began, as well as a pronounced decrease in mean size over the 20 year period from 1954-74.

Since 1974 though, the mean length of males has been steadily increasing, while the mean length of females has remained static. Analysis of variance and pairwise comparisons of means via the Tukey (HSD) test found no significant difference (.05) between mean total length of males captured in 1954-63, to males captures in 1995-97, but did find significant increases in length (.05) from 1975 to 1995. Females also experienced a significant decrease (.05) in

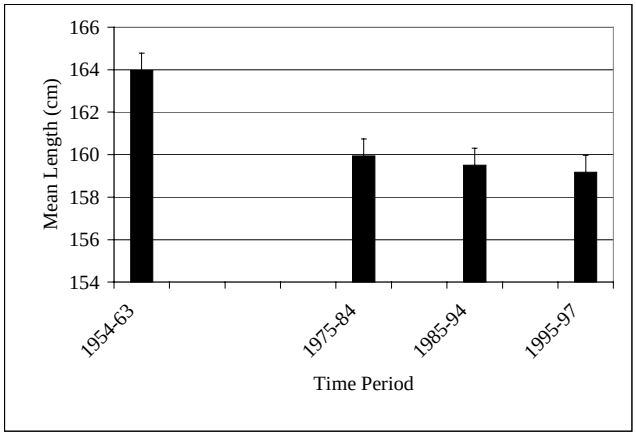

Fig. 7: Adult female lake sturgeon mean total length, Winnebago System, 1954-97

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total length from 1954 to 1975, but did not experience the increase in mean total length enjoyed by the males from 1975 to 1995. No significant differences were found between mean total lengths of females captured from 1975 to 1995.

Spear Harvest and Fishery, 1941-90

Harvest and Spearing Effort

Sturgeon harvest estimates for 1941-54 and registrations for 1955-90 for the Winnebago Pool Lakes are illustrated in Figure 8. Since mandatory registration began in 1955, annual harvests ranged from 8 fish in 1969 and 1973 to 3173 fish in 1995. Annual harvests averaged 1249 fish for the period 1955-59 dropping to a mean

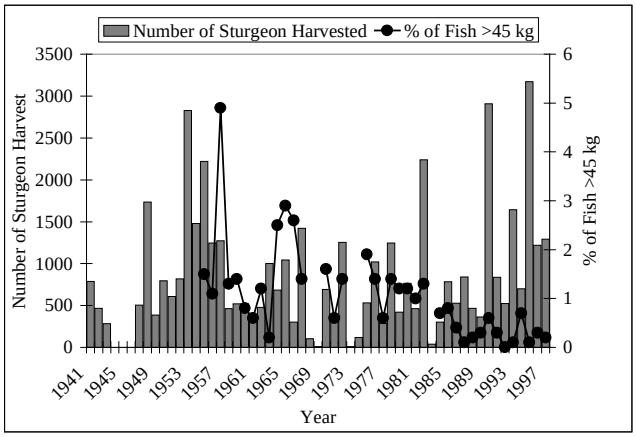

Fig. 8: Winnebago System lake sturgeon harvest, winter spear fishery 1941-97

annual harvest of 501 fish from 1960-64. Mean annual harvest within five year periods 1965-69 through 1985-89 remained between 510 fish per year and 761 fish per year. From 1990 through 1997 however, mean annual harvest increased to 1209 sturgeon registered per year.

Since aerial spearing shanty counts were first made on Lake Winnebago in 1956, the number of shanties has increased nearly 2.5 times from an average of 1602 or one shanty per 34.8 ha for the first four years of counts, 1956-59, to an average of 3661 or one shanty per 15.2 ha for the last four years, 1994-97 (Figure 9). Shanty counts in some years on Lake Winnebago are quite low due to poor ice condition, adverse weather, and/or poor travel condition on the ice. Shanty counts on the Upriver Lakes during the 16 seasons held there since 1952, show much higher densities than Lake Winnebago, with an average of 888 or one shanty per 12.5 ha from 1956-59 (three seasons), to a count of 1656, or one shanty per 6.7 ha during the last season held in 1996.

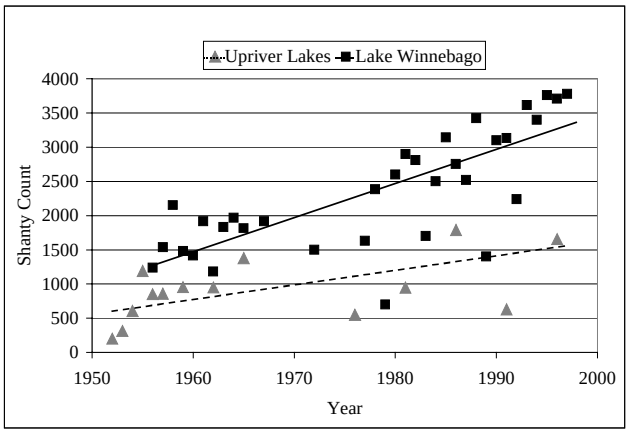

Fig. 9: Sturgeon harvest effort measured through ice shanty counts, Winnebago Pool Lakes 1952-97.

Estimated Exploitation

Exploitation of the spawning stock calculated for year periods from 1952-56 to 1992-96 showed a dramatic decrease in the estimated exploitation rate, from relatively high levels, for both sexes from the mid 1950' to the early 1960's, with a subsequent rise beginning in the mid 1980's (Figure 10). The increase in estimated exploitation in the mid 1980's was especially acute for mature females, peaking in the early 1990's. Since 1995 estimated exploitation rates for both sexes have decreased.

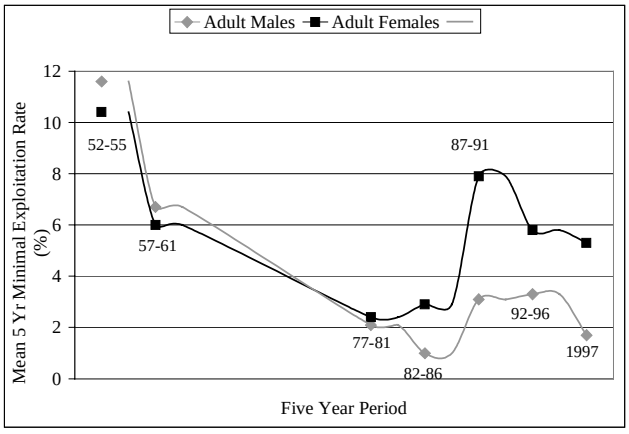

Fig. 10: Estimated minimal exploitation rates, Winnebago System lake sturgeon 1955-97.

Size and Age Distribution, and Condition of Harvested Sturgeon

Mean total length of harvested sturgeon has been steadily increasing

since 1951 from 125 cm in 1951-54 to 136 cm in 1955-64, and then again to 140 cm in 1974 (Figure 11). The increases coincide with increases in the minimum size limit from 76 cm to 102 cm in 1955, and from 102 cm to 114 cm in 1974-84. The increases in mean size from the period 1985 to 1995 coincides with the 1985 implementation and strict enforcement of the $1,500 fine for possession of an undersize sturgeon. Analysis of variance and subsequent pairwise comparison of means (HSD) found the increases in mean size of harvested fish resulting from the increases in the minimum length limit to be significant at the .05 level.

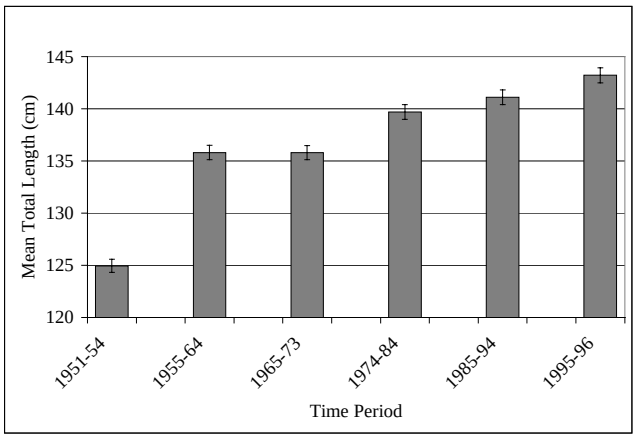

Fig. 11: Lake sturgeon mean total length, Winnebago System spear harvest 1951-96.

Length frequency distributions of fish harvested from the periods of the three different minimum length limits illustrate the changes in mean size and the shift in the mode of the distribution towards larger fish while the upper end of the frequency range remained static (Figure 12).

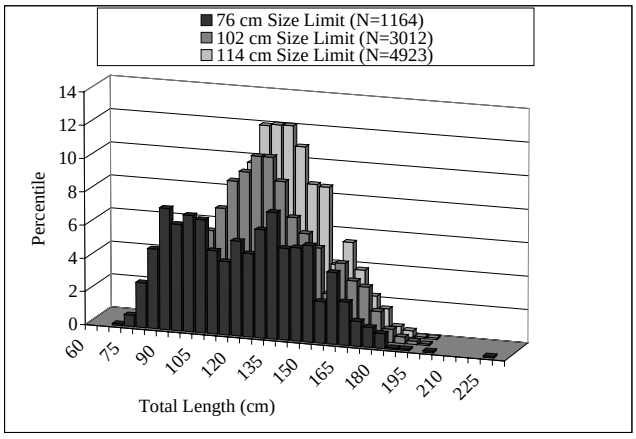

Fig. 12: Lake sturgeon total length frequency, Winnebago System spear harvest 1951-94.

Mean age of sturgeon harvested ranged from 23.3 years for the period 1991-96 to 19.8 years for the period 1965-69. The pattern of mean ages generally followed the pattern of mean total length of harvested fish - increasing as the size limit was increased. Mean ages of harvested fish along with minimum and maximum ages for seven sample periods from 1953 to 1996 are listed in Table 3. Analysis of variance and pairwise comparisons of means (LSD) found the mean age of sturgeon harvested in 1991-96 to be significantly higher (.05) than in any other period sampled. From 1953 to 1996 minimum ages of harvested fish increased from 6 to 10 while maximum ages, after initially rising from 49 to 75 (in 1960) consistently decreased to 51.

Table 3
Mean age, minimum and maximum age, sample size, and standard deviation of the mean for sturgeon harvested via the Winnebago System spear fishery 1953-96.

Time Period	Mean Age	Min-Max Age	N	SD
1953-54	20.6	6-49	738	8.5
1955-59	22.9	8-68	3981	7.5
1960-64	21.2	7-75	2522	8.8
1965-69	19.8	6-56	2745	8.8
1975-81	20.2	9-55	706	6.9
1982-90	22.2	11-55	239	7.3
1991-96	23.3	10-51	2828	5.2

Mean condition of harvested sturgeon remained relatively stable for the period from 1951-79 (Figure 13). Since 1980 condition has generally decreased, although also becoming slightly more variable. Condition has been calculated separately for harvested males and females since 1991, and while there are differences between the sexes with females generally having a higher mean condition, the mean condition of both sexes followed the same trend.

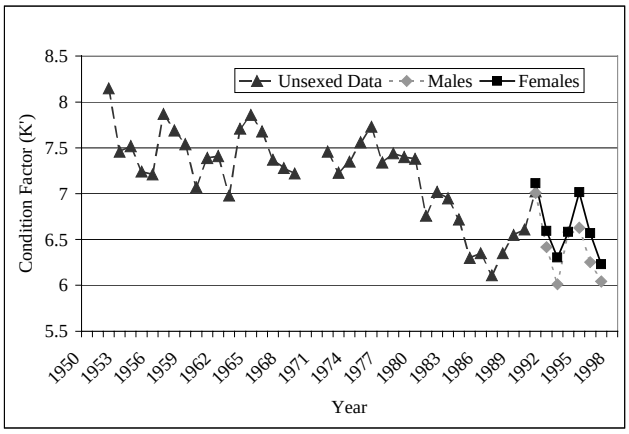

Fig. 13: Lake sturgeon mean condition factor (K), Lake Winnebago 1951-94.

Sturgeon Length at Age

Sturgeon length at age, using unsexed or combined sex samples, shows similar patterns from harvest aging data collected in 1954-56 and in 1993-94. Generally a 20 year old sturgeon from both periods would be approximately 134 cm, with a 35 year old fish being approximately 164 cm. The 1993-94 data did show greater lengths at age for fish between 20 and 35 years of age compared to fish of the same ages in 1954-56.

Estimated Total Annual Mortality Rates

Total annual mortality rates (A) calculated from catch curves developed on unsexed harvest aging data over the last 40 years, shows a sharp rise in estimated total annual mortality rates from 1953-54 (A=0.143) to 1955-59 (A=0.221), followed by a substantial decline in the rate, as measured in 1975-81 (0.098). Since 1981 though, the total annual mortality rate has risen sharply again to an

estimated A of 0.186 for the 1991-96 time period (Figure 14).

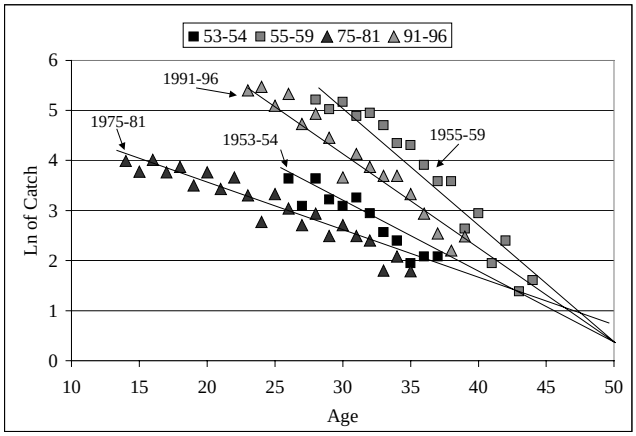

Fig. 14: Lake sturgeon catch curves, Winnebago System harvest data 1953-96.

Discussion

Status of the 1997 Winnebago System Lake Sturgeon Population and Fishery

The 1997 lake sturgeon population finds itself in the interesting dilemma of being at the crest of a four decade rise in densities, while at the same time experiencing apparent overexploitation of adult females exhibited by a nearly complete lack of large, old fish (>50 years of age) in the population. Males, on the otherhand, appear to be responsible for a large share of the density increases over the last 15-20 years, and have every opportunity to live to an old age, but do not as apparently their relatively high natural mortality rate results in few living past the age of 40. Recruitment (which is not measured) has obviously been good over the last forty years to allow for the buildup of the sturgeon stock - it has likely been enhanced by the spring Sturgeon Patrol and the 4 to 5 fold increase in Wolf River sturgeon spawning sites resulting from the placement of riprap shore protection. As a result of consistent recruitment, densities have increased but sturgeon biomass may have reached a level to effect a decrease in overall condition of sturgeon in the population. The decrease in condition though, does not seem to have impacted growth in terms of unsexed length at age. Fish that historically were consistently found to have the lowest condition were many (but not all) of those harvested during the Upriver Lakes spearing seasons, which led early biologists to believe that the Upriver Lakes population was distinct from the Lake Winnebago sturgeon population. Tag return data over the past 15 years (DNR files, Oshkosh) and recent Wolf River surveys (Bruch, Wolf River sturgeon assessments, 1994-96) strongly indicate that the Upriver Lakes sturgeon population is not a separate stock as previously thought, but instead a nursery stock of juveniles that are gradually working their way down to Lake Winnebago over a 10 year period. These new data suggests that the most appropriate strategy for management of the Winnebago sturgeon population and fishery is from a system-wide perspective.

The spear fishery on both Lake Winnebago and the Upriver Lakes has grown in popularity and annual harvests have risen since 1990 to the point of concern, especially regarding the harvest of adult females. Improvements in water quality, likely the result of a number of water quality improvement actions over the last two decades, such as sanitary sewers, urban stormwater management, and implementation of agricultural erosion and waste controls, have resulted in more seasons with good winter water clarity. As water clarity has improved the average annual harvest has increased. Newly documented pre-spawn migration patterns strongly suggest that females (adults and juveniles) have likely always made up a substantial portion of the spearing harvest from Lake Winnebago. Sex and maturity data collected on the harvest since 1991 has provided key insights into the actual impact of the spear fishery on the sturgeon population, with the realization that with a 114 cm size limit, adult females have been making up nearly half of the harvest while only comprising a relatively small portion of the harvestable population. Record shanty counts have been set in three of the last five years and shanty occupancy rate has likely also increased with an observed increase in immediate family members, children and grandchildren, entering the fishery in the last 10 years. The current estimated total annual mortality rate for females, 17.3%, and relatively high recent mature female exploitation rate are further evidence that the harvest patterns are affecting the female stock.

Long Term Impact of Harvest Regulations

Reviewing the history of regulations enacted to control or shape the sturgeon harvest on the Winnebago System is vital to understanding how we arrived at the sturgeon population we have today, as well as to understanding which regulations result in the desired impact and which ones do not. Of course having a time series of sound population and harvest assessment information is critical to examining the impact of regulations. Also, having adequate enforcement of and compliance by users of, existing regulations is critical to ensuring the regulations are having the desired impact.

While no data exist to verify the effectiveness of the harvest ban enacted in 1915, just the act itself does indicate that the Wisconsin state government at the time adopted the philosophy, or better yet, an attitude that sturgeon stocks in the state had value and needed protection. When sturgeon harvest was finally legalized again on the Winnebago System in 1931 bag and size limits were set that were likely thought at the time to be reasonable yet restrictive enough to provide some protection to the stock. Poaching was said to be widespread throughout this time period. Even though conservation wardens had been enforcing laws since the turn of the century, their numbers were relatively low and areas quite large (K. Corbett, DNR, personal communication). In the early 1940's the first biologists were hired to study the Winnebago sturgeon stocks and evaluate the effectiveness of harvest regulations.

The first comprehensive set of regulations enacted with a complement of biological assessment data allowing for evaluation were those implemented in the 1950's when the set line and hook and line seasons were closed, the spearing season was shortened, the seasonal bag limit was reduced to one fish, and the minimum size limit was increased. The Upriver Lakes spearing season was also opened but within 10 years was scaled back to a two day season once every three years. At that time there were still fish in the population that hatched in the 19th Century. The most obvious and immediate impact of the enactment of these rules was a 58% reduction in the average annual harvest. The primary goal of harvest reduction had been attained likely as a result of the decreases in season length and bag limit. While the increase in the minimum size limit from 76 to 102 cm may have been responsible for some of the harvest reduction and seemed reasonable at the time, the increase definitely shifted spearing effort on to larger fish. A

sharp rise in the total annual mortality rate in the late 1950's coincides with the increase in the size limit despite the 58% reduction in overall numbers of fish harvested.

In the early 1970's biologists and conservation wardens were still concerned about immature sturgeon being harvested in the spear fishery, and enacted another increase in the minimum size limit in 1974 from 102 to 114 cm in an effort to protect the fish until they could reach the size of maturity. This increase further squeezed increasing spearing effort on to even larger fish that comprised an even smaller component of the entire sturgeon population. As the average size of the fish in the harvest increased, the relative number of large trophy fish in the population, and thus in the harvest, decreased. The trend of increasing average size of harvested sturgeon accelerated with the 1985 enactment of the $1500 fine for possession of an illegal or sublegal size sturgeon. This fine typically grows to $3000 after adding court and other associated costs. From 1974 to 1985, with the relatively low fine during that time period, it is likely that spearers may not have been as careful in judging whether a sturgeon coming "through their hole" was legal size or not. It is also likely that from 1974 to 1985 some number of sublegal fish were taken off the lake without being registered. The implementation of the $1500 fine did make spearers better judges of the size of sturgeon swimming through their ice holes, but mistakes undoubtedly did happen from time to time, probably resulting in the fish being "kicked off" the spear and back down the hole. While there are no records of the number of fish kicked off, surveys conducted by Sturgeon for Tomorrow indicate that in some years the "kick off" rate could be as high as 25% to 30% of the harvest (W. Casper, Sturgeon for Tomorrow, personal communication). Despite whatever spearing mortality was occurring in the 1980's though, the legal stock of sturgeon was growing in numbers and estimated total annual mortality rates were relatively low, although we do not know what the sex-specific effect of "kick offs" in the Lake Winnebago spear fishery was.

Greater frequency of clear water winters in the late 1980's and into the 1990's resulted in a number of record or near record harvests. Exploitation of adult females tripled and the overall total annual mortality rate doubled. Using expanded harvest assessment data including sex and maturity of harvested fish, another set of comprehensive regulation changes similar in scale to those enacted in the 1950's were enacted between 1992 and 1997. The spearing season was shortened to nine days in 1996 and then to a set 16 days in 1997 and the minimum size limit was decreased from 114 to 91 cm. Other regulations included a strengthening of laws on the transportation of unregistered fish and use of spearing shanties before the spearing season, a prohibition of angling in a spearing shanty, and a reduction of the daily sturgeon registration hours. The package was enacted as Phase 1 of an effort to develop and implement a comprehensive Safe Harvest Management Program for the lake sturgeon population of the entire Winnebago System including the Wolf and upper Fox Rivers and the Upriver Lakes. The impact of the new regulations was seen in 1997 with adult females dropping from 46% of the harvest with a 114 cm minimum size limit and longer season, to 34% of the harvest with a 91 cm size limit and a shorter season, and seeing the exploitation of adult females decreasing to the recommended 5% level.

Phase 2 of the new regulation package will involve management of the two day Upriver Lakes harvest which is scheduled to occur again in the year 2001. Continued aggressive harvest and population assessment will allow other short term impacts to be determined, as well as allow potential long term impacts to be forecast with some degree of confidence.

The vital components contributing to the success of the Winnebago Sturgeon Management Program are:

1) Sound, long term, biological assessment of the lake sturgeon population and harvest. As those that work on sturgeon know, it generally takes decades of consistent data to determine trends and the lasting impacts of management actions and/or regulations with these species. Sound assessments conducted fairly consistently since the 1940's provide a strong data base for decision making.

2) Strong, effective enforcement of harvest and other resource protection laws. Conservation law enforcement officials have made a commitment and a consistent effort to enforce sturgeon harvest and habitat protection laws.

3) Sincere, meaningful involvement of the "sturgeon" public in the overall development and implementation of the sturgeon management program. This involvement needs to be facilitated by the responsible government agency and also needs to be comprehensive enough to involve all significant sturgeon interests with a stake in the management of the common stock of sturgeon. The DNR has made a commitment to actively involve sturgeon interests in the management program through the Sturgeon Advisory Committee, sturgeon workshops and presentations, and various information/education activities. Public interest, energy and resources may also manifest themselves in organizations like Sturgeon for Tomorrow which can be tremendous allies in developing and implementing an effective sturgeon management program.

4) Protection and enhancement of sturgeon habitat within the Winnebago System and natural reproduction. Fortunately dams built on the system were placed far enough upstream that the impact on sturgeon is negligible, and the fact that Winnebago has a long tradition of the sturgeon spear fishery and population has helped to prevent placement of new dams and other losses of critical habitat. The population has remained robust, despite some harvest problems, due to strong, consistent natural reproduction.

Public Involvement in Sturgeon Management

If it were not for the desire of individuals to harvest sturgeon there would, of course, be no need for a management program. As a natural fishery resource, sturgeon have various values, which have also somewhat changed over time. These values motivate harvest, which in turn, due to the sturgeon's high susceptibility to overharvest, put sturgeon stocks at some level of threat from overexploitation. Regulations attempt to limit harvest as well as protect the habitat the fish depend upon, but regulations are only as effective as the effort put into enforcing them and the willingness of the users to comply with them. The responsible government must make a commitment to management and to enforcement. The users also need to make a commitment to sturgeon preservation and regulation compliance. Providing the government has made a real

commitment to management and enforcement, a management system is most likely to break down at the user level with users not accepting and/or understanding the management program and not complying with harvest regulations. The challenge, which of course becomes more complex in interstate or international situations, is to effectively involve the various parties interested in a sturgeon stock in the assessment of management issues and the development and implementation of management strategies and actions. The Winnebago System Sturgeon Management Program is a case study, albeit a relatively simple one compared to some of the complex issues biologists are attempting to deal with in the Caspian or in Europe, which can perhaps provide some basic insight into how a management program working with the pubic can be made most effective. Sturgeon assessment data, habitat protection and enhancement, regulations and enforcement are all made more effective when the "users" have understanding and ownership of the resource and the management strategies designed to positively affect the resource.

Synopsis

The lake sturgeon population and fishery of the Winnebago System has been the subject of an evolving, living management program that has attempted to address key issues of the day and has provided relative long term stability to the sturgeon stocks. The incremental and iterative management and regulatory actions taken since 1903 were likely always made with the best available data and understanding of those data at the time. A number of decisions and actions stand out as key events in the development and maturation of the Winnebago sturgeon management program:

* prohibiting sturgeon harvest in 1915,
* reopening harvest seasons in the early 1930's,
* hiring of professional biologists in the late 1940's,
* closing the set line fishery in 1952,
* decreasing the seasonal bag limit from 5 to 1 and shortening the harvest season in the late 1950's,
* implementing mandatory registration of harvested fish in 1955,
* the establishment of Sturgeon for Tomorrow in 1977 as a citizen advocacy group for sturgeon management and research,
* implementing the "Sturgeon Patrol" in 1977 to protect spawning fish,
* initiating the $1500 fine in 1985 for the possession of illegal sturgeon,
* expanding the sturgeon harvest and population assessment in 1991 to include sex and maturity of harvested fish,
* establishing the Winnebago Citizens Sturgeon Advisory Committee in 1992 to assist in the development of and compliance with new regulations and management actions,
* shortening of the season in 1996 and 1997, and
* reducing the size limit in 1997.

The current population of sturgeon in the Winnebago system is a product of the aforementioned decisions and actions, and therefore a living testament to the effectiveness of those decisions and actions. While there is currently some concern about the long term stability of the female spawning stock, the Winnebago System Sturgeon Management Program is addressing those concerns with the management, public involvement, and regulatory actions taken from 1991 through 1997.

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