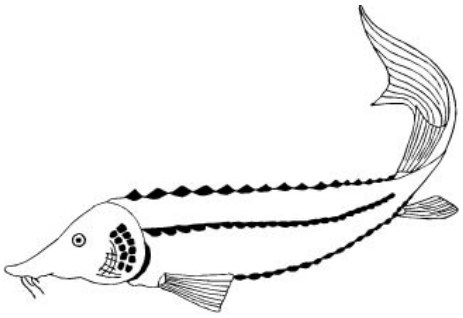
A LAKE STURGEON REHABILITATION PLAN FOR LAKE SUPERIOR



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A LAKE STURGEON REHABILITATION PLAN FOR LAKE SUPERIOR

edited by

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ABSTRACT

The goal for lake sturgeon (*Acipenser fulvescens*) rehabilitation in Lake Superior is to maintain, enhance and rehabilitate self-sustaining populations where the species historically occurred basinwide. The lack of information on the biological characteristics and population abundance of lake sturgeons has limited management decisions. A self-sustaining population of lake sturgeons is defined as one with a minimum of 1,500 mature adults using a common tributary for spawning, a roughly equal sex ratio, 20 or more year-classes of adult fish, evidence of annual reproduction through collection of viable eggs, and measurable recruitment of age 0-5 fish. Management of lake sturgeons should include the protection and rehabilitation of habitat for all life stages in 17 tributaries, 16 embayments, and corridors for movement throughout the nearshore area. Achievement of the rehabilitation goal will require regulation of the harvest to maintain annual exploitation rates at less than 5%, continued development of sea lamprey management technologies to ensure minimal negative impact on lake

sturgeons, protection of existing habitat, restoration of degraded habitat, provision of passage upstream and downstream of man-made barriers, and increased public awareness. Measuring progress toward the rehabilitation goal will be accomplished by monitoring the density of adults in spawning tributaries, the presence of drifting larvae in spawning streams, the presence of juveniles in nearshore habitats, and the capture of adults at historical spawning sites. Tissues collected for genetic and contaminant studies should be analyzed. Lake sturgeons should be stocked in historically important tributaries that contain suitable habitat for spawning but currently are not being occupied. Lake Superior brood stock should be used for stocking purposes. Future research should focus on the collection of basic biological information on lake sturgeons, community interactions, and uniform and frequent population assessments.

INTRODUCTION

In 1994, the Lake Superior Technical Committee (LSTC) and Lake Superior Committee formed the Lake Sturgeon Subcommittee (LSS) (Appendix A). The LSS was charged with describing the current status of and developing a rehabilitation plan (Plan) for lake sturgeons (*Acipenser fulvescens*) in Lake Superior. A report describing the status of lake sturgeons in Lake Superior (Status Report) was submitted to the LSTC and accepted in January 1997 (J. Slade, Ludington Sea Lamprey Control, 229 South Jebavy Drive Station, Ludington, MI, 49431, personal communication).

This Plan describes the LSS objectives for lake sturgeon rehabilitation by identifying and summarizing rehabilitation goals and management strategies to reestablish or enhance lake sturgeon stocks in the lake. The Plan is based on information compiled in the Status Report and scientific and technical knowledge from the literature, combined with the expertise of LSS members and of other fishery resource managers.

Lake sturgeons are the only sturgeon species endemic to the Great Lakes. They are also the largest and longest lived fish species in the Great Lakes. In Lake Superior, lake sturgeons are distributed throughout the basin with concentrations found near spawning tributaries in both the United States and Canadian jurisdictions. Currently, nine Lake Superior tributaries are known to support self-sustaining lake sturgeon populations. These tributaries include:

- Sturgeon River, Michigan
- Bad River, Wisconsin
- Big Pic, Black Sturgeon, Goulais, Gravel, Kaministiquia, Michipicoten, and Nipigon Rivers in Ontario

Abundance in all these rivers is reduced from historical levels but current population assessment and information on basic biology is lacking.

There are no quantitative estimates of lake sturgeon abundance in Lake Superior prior to data collected from commercial harvests targeted at them in the 1880s. It is thought that lake sturgeon populations actually began to decline during the mid-1800s (Brousseau and Goodchild 1989) because of:

- Habitat degradation caused by logging operations
- Harbor construction and shipping at river mouths
- Incidental catch by the commercial fishing industry

Lake sturgeons were abundant enough to support a commercial fishery until the early 1900s when lake sturgeon abundance declined precipitously because of an expanded harvest (Baldwin et al. 1979; Rochard et al. 1990).

Throughout the 1930s, the combined effects of exploitation, degradation of water quality and habitat, construction of hydroelectric dams, and other barriers to migration were responsible for further declines in lake sturgeon abundance. Industrial developments (such as pulp mills) limited the food supply and buried spawning beds (Harkness and Dymond 1961). Despite restrictions on commercial exploitation early in the 20th century, improved water quality, and tributary-specific management efforts in the mid-1900s, lake sturgeon populations in Lake Superior still have not fully recovered from the early declines. In addition to the population decline, sturgeon rehabilitation will be difficult because of:

- Late age at sexual maturity (15-20 years)
- Intermittent spawning (2-7 years)
- Locally extirpated spawning populations

MANAGEMENT AREAS

The LSS recognizes 17 tributaries to Lake Superior (priority streams) where lake sturgeon rehabilitation should be focused (Fig. 1). Critical management areas within the Lake Superior basin include all nearshore areas and ten rivers within the four management jurisdictions of Ontario, Michigan, Minnesota, and Wisconsin. There are seven additional rivers for which restoration is either in progress or suggested.

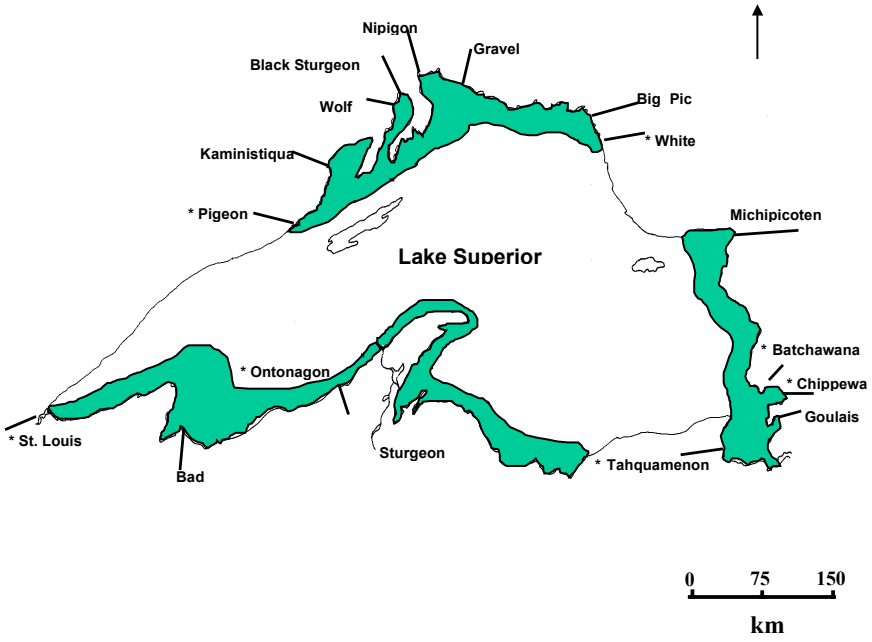

Fig. 1. Critical management areas for lake sturgeon in the Lake Superior basin. Asterisks (*) indicate rivers that may require or are undergoing re-introductions of lake sturgeon.

GOALS FOR RESTORATION

Goals for the restoration of lake sturgeons were established and management strategies to achieve these goals were identified. The goal for lake sturgeon rehabilitation in Lake Superior is "to maintain, enhance and rehabilitate self-sustaining populations where the species historically occurred basin-wide." A self-sustaining population is defined as a group of fish that ascends a common tributary to spawn each year. There should be at least 1,500 mature, spawning adults capable of ascending a common tributary to spawn, even though not all of them spawn each year. The objective of 1,500 adults is derived from information collected on the Sturgeon River, Baraga County, MI (N.A. Auer, Department of Biological Sciences, Michigan Technological University, Houghton, MI,

unpubl. data). The Sturgeon River has an average annual flow of about 17-20 m^3/s (600-700 cfs) at Prickett Dam where many of the fish spawn. Large tributary systems such as the Bad, St. Louis, and Nipigon Rivers may support more than 1,500 adults, and small tributaries may support fewer. Management strategies include:

- Harvest controls
- Protection and rehabilitation of habitat for all life stages
- Greater understanding of population biology and genetics
- Increased assessment
- Development of a reliable Lake Superior egg source
- Regulated stocking
- Increased public education efforts

This Plan recognizes four habitat types in Lake Superior:

- Offshore (depth > 80 m (260 ft))
- Nearshore (depth < 80 m (260 ft))
- Embayments
- Tributaries

The stresses to lake sturgeon populations are different in each zone and tend to increase from the nearshore area to tributaries. There are no known records of lake sturgeons in the offshore areas. In the nearshore habitat, stresses include dredging, barriers to migration and forage

corridors, and sea lamprey predation on subadults and adults. Embayments include areas segregated from the main basin of the lake but that are subject to lake seiches (Appendix B). Stresses in embayments include dredging, breakwalls, vessel discharge, industrial discharge, and filling of wetlands and sloughs, all of which can affect larvae, juveniles, subadults, and adults. Most stresses to lake sturgeons occur in tributaries and affect all life stages. They include barriers, regulated flows, water removal for agriculture, point and nonpoint discharges, and sea lamprey treatments (Appendix C). There are five life stages of lake sturgeons that may be affected by stresses in each habitat type:

- Eggs
- Larvae < 34 mm long (age 0)
- Juveniles 35-599 mm long (ages 0-5)
- Subadults 600-999 mm long (ages 5-15)
- Adults > 999 mm long (ages > 15)

ISSUES AND STRATEGIES

Issue 1—Harvest Management

Exploitation rates should be monitored in all management areas. Extensive analyses of harvest data gathered on the Lake Winnebago, Wisconsin, lake sturgeon population over the last 40 years have shown that the total annual mortality rate ranged from 10%-22% (Bruch 1999), and that the exploitation rate should be maintained at or near 5% to protect a self-sustaining population (Bruch 1999). Based on this information, the LSS recommends that a conservative management approach be adopted with the goal of keeping exploitation rates less than 5% on all lake sturgeons. Most management agencies on Lake Superior have prohibited commercial harvests. However, First Nations in Ontario

and some native American bands in the United States permit subsistence or home-use harvest. Sport fishing is permitted in Wisconsin and Ontario waters, and agencies should monitor these catches annually. The degree of lake sturgeon exploitation by sport and commercial fisheries for other species is currently not known but is believed to be limited.

Harvests should be monitored and either a conservative harvest, or no-harvest (catch and release) regulation should be considered for the rivers and bays where lake sturgeon populations are being rehabilitated. As populations increase in abundance over time, regulations can be tailored to specific populations. In areas where lake sturgeons are successfully rehabilitated, agencies are encouraged to develop regulations that prevent populations from declining. Determining an allowable harvest level will require additional biological information on:

- Population size
- Age structure
- Age at maturity
- Geographic range

If data are not available, agencies should prohibit harvest until adequate biological databases are developed.

Harvest Management Strategies

The harvest management strategies are:

- Quantify the natural mortality of lake sturgeons in Lake Superior
- Develop adequate measures to protect spawning sturgeons
- Limit harvest and catch in areas where rehabilitation is in progress and closely monitor harvest; after stocks are self-sustaining, harvest options should be carefully considered; mandatory registration within each jurisdiction will supply information needed to determine harvest level
- Adopt harvest regulations that are compatible across jurisdictions if research and assessments show that sturgeons from discrete spawning populations intermingle
- Protect concentrations of adults in areas where they aggregate prior to spawning

Issue 2—Spawning and Nursery Habitat

Critical habitat includes spawning, nursery, rearing and foraging habitat, and migration routes. Agencies should identify and quantify critical habitat necessary for lake sturgeon reproduction and survival and rehabilitate and protect such areas throughout the species' historic range. Because lacustrine lake sturgeon populations ascend rivers for spawning, habitat rehabilitation and protection efforts should be directed at the rivers that presently support, and/or have historically supported, spawning populations. A critical component of spawning habitat is a natural stream flow regime (Auer 1996), so ensuring adequate and naturally fluctuating flow during the spawning period should be a priority for all management agencies. Many of the rivers that once supported lake sturgeon spawning runs and egg incubation have been radically altered by construction of hydroelectric power dams, changes in

land use, timber harvest practices, and other human activities. Restoration of degraded spawning habitats, including removal of, or passage around, barriers will be necessary to restore lake sturgeons to their former range. Past and present habitat conditions should be assessed using aerial photos of vegetation, physical and man-made structures, and wetlands surveys, where available, to determine whether replacement, enhancement, or renewed accessibility to habitats may be necessary. Habitat restoration is already a priority for the:

- Ontonagon River, Michigan, because of loss of all wetland habitats

- Black, Michipicoten, and Wolf Rivers in Ontario because of barriers to migration and spawning

Spawning and Nursery Habitat Strategies

The spawning and nursery habitat strategies are:

- Protect self-sustaining populations of lake sturgeons currently found in nine Lake Superior tributaries (Fig. 1) by maintaining suitable habitat and rehabilitating degraded areas

- Reestablish lake sturgeon populations through habitat enhancement and protection and judicious stocking in tributaries that are known to have had historic populations

- Describe the nursery habitats and habitat requirements of newly hatched and juvenile lake sturgeon so that such areas can be protected from further development

- Establish relicensing criteria for hydroelectric facilities to ensure:
  - Run-of-river flows in riverine reaches
  - Adequate flow within the bypass of bypassed river channels
  - Appropriate annual water regime for lake sturgeon reproduction and survival
- Describe the annual movements of adult lake sturgeons into and out of individual spawning tributaries and nearshore waters; identify spawning sites and describe both the biological and physical conditions of known spawning areas
- Evaluate the degree of damage to tributaries that have been identified for rehabilitation; sediments covering spawning habitat should be removed and replaced by large woody debris or other appropriate cover material; reforestation of stream banks should be considered
- Describe the movements of larval lake sturgeons and the time period during which juveniles occupy spawning tributaries to determine when construction projects (road crossings, bridge construction, etc.) and lampricide treatments will have minimal negative impact; management agencies should work with county, city, state, and provincial departments of transportation to establish time windows when construction and repair projects should be undertaken
- Identify and evaluate all point sources of pollution and irrigation intakes in watersheds containing lake sturgeons and note any detrimental effects to aquatic life
- Determine the origin of fish captured in embayments and nearshore areas of Lake Superior through tag return reports and telemetry studies

Issue 3—Stocking and Genetics

The LSS recommends stocking lake sturgeons only in the priority streams that have had historic spawning populations but are currently not occupied. Stocking should be undertaken concurrently with exploitation controls and with habitat protection and restoration. Stocked streams should have substrate, flow regimes, and temperatures that support natural reproduction. Until more is known about the genetic structure of Lake Superior sturgeon populations, agencies are encouraged to stock only lake sturgeons of Lake Superior origin. Before a stocking program is implemented, fish-health issues should be considered to prevent introduction of unwanted pathogens. If stocking is pursued as a management strategy, priority should be given to the:

- Ontonagon River, Michigan
- St. Louis River, Minnesota/Wisconsin
- Pigeon River, Minnesota/Ontario
- Batchawana, Chippewa, and White Rivers, Ontario

Genetic research on lake sturgeon has not identified genetically distinct populations in Lake Superior, although there are genetic differences among lake sturgeon populations within the three major drainages that support lake sturgeons: Hudson Bay, Mississippi River, and the Great Lakes (Fields et al. 1997). Genetic differences are also likely to be found within drainages (Staggs et al. 1996). Because of the late age of sexual maturity and intermittent spawning cycle, the capture of wild adults during spawning runs remains the most reasonable method of obtaining gametes for artificial propagation. Potential sources for brood stock are the Bad, Sturgeon, Kaministiquia, and Gravel Rivers. Two Lake Superior tributaries—the Sturgeon River in Michigan and the Bad River in Wisconsin—have been used as sources for lake sturgeon eggs. The Bad River and Red Cliff Bands have the capability to rear lake sturgeons at their hatchery facilities. To date, fish from the Sturgeon River have been stocked in the St. Louis River in Minnesota/Wisconsin and the Ontonagon River in Michigan. Fish from the Bad River have been returned to the Bad River to augment the population.

Stocking appears to have been successful in western Wisconsin waters (Schram et al. 1999); however, recruitment has not been observed and the importance and timing of imprinting in young sturgeon is still uncertain. To optimize the success of rehabilitation efforts, both larvae (15-30 mm) and fingerlings (100-250 mm) should be stocked**.** All stocked fingerling sturgeons should have a mark/tag to monitor stocking success. Spawning operations should follow a brood-stock management plan to maximize genetic variability. The annual establishment of year-classes consisting of marked individuals at historic spawning sites and subsequent recruitment in three of every five years over a 20-year period will determine stocking success.

Stocking and Genetic Strategies

The stocking and genetic strategies are:

- Evaluate, through regular coordinated assessments, the impact that stocking lake sturgeons has on remnant populations

- Determine optimal stocking and survival rates; continue to quantify and document the results of the larval and fingerling stocking program in the St. Louis River in Michigan/Wisconsin

- Determine if lake sturgeons imprint on spawning tributaries and, if so, at what life stage

- Determine mark/tag types for planted lake sturgeons that will facilitate identification of stocked fish; a uniform marking strategy (across all jurisdictions) for marking all adult fish and keeping detailed records of all fish used in egg-takes is suggested

- Conduct genetic analyses of as many Lake Superior lake sturgeon populations as possible and describe the genetic variability within and among populations in the Lake Superior basin, the Great Lakes, and other regions of North America; wild brood stock should be bred and distributed following principles designed to maximize the genetic variability of the progeny and minimize genetic drift and inbreeding, as described in Ryman and Utter (1987)

- Establish hatcheries capable of raising lake sturgeon and develop methods that would allow collection of brood stock from more than one or two tributaries

Issue 4—Contaminants

The levels of heavy metals and other contaminants in Lake Superior lake sturgeons are currently unknown. Contaminants tend to concentrate in fish such as lake sturgeons that grow slowly and live a long time. How contaminants in the Great Lakes affect lake sturgeon survival and reproduction is an area requiring further research. For the Lake Superior region, chlordane, mercury, toxaphene, DDT, and PCBs are the primary contaminants of concern.

Contaminants Strategies

The contaminants strategies are:

- Develop a protocol for conducting contaminant analysis of lake sturgeon eggs and of any juveniles and adults that are either incidentally killed or confiscated by enforcement officials

- Identify, monitor, and reduce contaminant discharges into the Lake Superior watershed; work in conjunction with the Lake Superior Binational Program in its basinwide initiatives for zero discharge

Issue 5—Sea Lamprey Control Practices

Control techniques—for example, chemical treatment and construction of barriers—aid in suppressing sea lampreys but may also suppress lake sturgeons and interfere with rehabilitation programs. Bioassays showed that young lake sturgeons are sensitive to the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) at concentrations that were applied to streams to kill sea lamprey larvae (Johnson et al. 1999; Boogaard et al. In Press). Low-head barriers designed to block upstream movement of sea lampreys also prevent upstream movement of adult lake sturgeons during spawning migrations. Fishways and other methods of transfer of sturgeons across barriers are only now being designed and tested (Peake et al. 1997). Fishery agencies need to work closely with the sea lamprey control program to minimize the risk to lake sturgeons from both lampricide treatment and barriers constructed in spawning tributaries.

Sea Lamprey Control Strategies

The sea lamprey control strategies are:

- Schedule lampricide treatments and apply lampricides at concentrations that minimize risk to larval and juvenile lake sturgeon

- Consider fishways and trap-and-transfer facilities at sea lamprey barriers that block lake sturgeon migrations

Issue 6—Ecological Interactions

Lake sturgeon and many other fish species feed on a variety of benthic aquatic invertebrates. Historic and current changes in the fish community may increase competition for food resources thereby limiting growth, survival, and distribution of lake sturgeon. Introduced non-native, exotic species may compete for food sources and/or prey upon lake sturgeon—particularly at early life stages.

Ecological Interaction Strategies

The ecological interaction strategies are:

- Assess and monitor nearshore invertebrate populations to determine potential food limitations for both juvenile and adult lake sturgeons in areas where populations and recruitment remain low after rehabilitation measures have been implemented

- Examine predation on lake sturgeon eggs by other species

- Quantify predation on drifting lake sturgeon larvae

- Quantify levels of sea lamprey wounding on lake sturgeon and estimate potential mortality rates

Issue 7—Public Education

The LSS recognizes the need to increase public awareness and knowledge about lake sturgeons to ensure support of rehabilitation efforts and to increase public involvement in collecting information on this fish. Lake sturgeons are not familiar to the public. Educational brochures, posters, and other resources highlighting the many unique and unusual characteristics of lake sturgeons will help increase public knowledge and could be distributed at community venues—for example, sport-fishing events, school programs, and tribal meetings. There is also a need to publicize habitat-improvement programs (either under way or planned) designed to rehabilitate lake sturgeons.

Public Education Strategies

The public education strategies are:

- Seek funding to develop educational brochures, posters, speaking opportunities, educational videos, CDs, radio and television announcements, and websites highlighting the many unique and unusual characteristics of lake sturgeons and the rehabilitation strategies presented in this Plan; the U.S. Fish and Wildlife Service and the Minnesota, Michigan, and Wisconsin Departments of Natural Resources have developed websites for lake sturgeon information and education

- Distribute educational materials about lake sturgeon widely within communities

- Seek and develop cooperative efforts with existing educational facilities and organizations

ASSESSMENT NEEDS

Historically, agencies have focused their assessment activities in either the nearshore waters of Lake Superior or cold-water tributaries primarily to collect information on higher profile and socioeconomically important species—for example, lake trout and Pacific salmon *(Oncorhynchus kisutch)*. Few financial or personnel resources have been focused on lake sturgeons. As a consequence, there is insufficient information available on either the biological characteristics or population abundance of lake sturgeons (J. Slade, Ludington Sea Lamprey Control, 229 South Jebavy Drive Station, Ludington, MI, 49431, personal communication). Until this information is known, it will not be possible to develop workable management strategies. The LSS believes it is very critical that agencies include lake sturgeon population assessments in their survey plans and collect as much biological and catch information on lake sturgeon as possible, within fiscal constraints. Because lake sturgeon abundance is still low, agencies should release live lake sturgeons caught during assessment activities after collecting biological information.

Assessment Strategies

The assessment strategies are:

- Refine techniques and gear to adequately sample and assess all life stages in tributaries and the lake; collect information—for example, length girth, sex, maturity, and diet; collect pectoral fin rays for ageing purposes and tissue samples for genetic studies

- Develop a lakewide protocol for sampling the various life stages of lake sturgeons

- Estimate recruitment of juvenile lake sturgeons to the adult population either annually or at regular (less than five years) intervals

- Coordinate the collection, analysis, and reporting of information among agencies and establish a uniform marking/tag recapture database for all agencies

- Develop an index of abundance for each major tributary including: Big Pic, Black Sturgeon, Goulais, Gravel, Kaministiquia, Michipicoten, Nipigon, St. Louis, Bad, Ontonagon, Sturgeon, and Tahquamenon Rivers; consolidate historic information on the species' relative or absolute abundance

- Monitor the catch, effort, and harvest of lake sturgeons in all significant fisheries

- Estimate concentrations of major contaminants (for example, PCBs, dieldrin, and mercury) in lake sturgeons

- Evaluate gears that will reduce mortality of nontarget fishes

RESEARCH AND MANAGEMENT NEEDS

Effective management of lake sturgeons in Lake Superior will depend upon collecting basic biological information, estimating the quantity and distribution of habitat, and determining the level of harvest that will allow the achievement of rehabilitation objectives. At present, little is known about current exploitation rates, and information on habitat quantity and quality is sketchy, at best. The following research and management needs are necessary to rehabilitate lake sturgeons in Lake Superior and are listed in order of priority:

- Determine habitat requirements and movement and dispersal patterns of all life stages

- Identify genetic variability within and among populations in Lake Superior and other populations

- Locate egg brood stock and rearing facilities and determine appropriate life stages and numbers of each life stage to stock

- Estimate historic and present status of lake sturgeon populations in Lake Superior and determine if spawning occurs in lake environments

- Determine the impact of stocked lake sturgeons on remnant populations; quantify and document the results of larvae and fingerling stocking in the St. Louis and Ontonagon Rivers

- Estimate current exploitation and mortality rates, determine mortality of lake sturgeon due to entanglement in commercial fishing gear, and require registration of all harvested fish with jurisdictional management agencies

- Determine if lake sturgeons imprint on spawning tributaries and, if so, at what life stage

- Identify suitable techniques for capturing juveniles that limit mortality of nontarget fishes

- Quantify predation on drifting larvae

- Evaluate the effects of contaminants on growth, reproduction, survival, and body burden

- Develop a partnership with the Superior Work Group of the Lake Superior Binational Program

- Continue to evaluate the effect of lampricides on lake sturgeon larvae and the effect of lamprey predation on sub-adult and adult lake sturgeons

- Determine if there are any levels of harvest that do not affect rehabilitation and if there are strategies that allow sustainable harvests both during and after rehabilitation

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APPENDIX A

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APPENDIX B

Embayments Important to Lake Sturgeon in Lake Superior

Harbor and/or Bay	Life Stage	Most Recent Observation	Estimated Area and Depth
Grand Portage Bay, MN	Subadult	1995	—
St. Louis, MN/WI	Adult, subadult, juvenile	1997	4600 ha 11 m (36')
Chequamegon, WI	Adult, subadult, juvenile	1997 1995	6.1 m (20') 4 m (13')
Bete Gris, MI	Adult	1993	9 m (30')
Huron, MI	Adult	1993 and 1995	1-3 m (3-10')
Keweenaw, MI	Adult, subadult	1987-1996	9-30 m (30-100')
Misery, MI	Adult	1993-1995	9 m (30')
Munising, MI	Adult	1989, 1991	23 m (75')
Whitefish, MI	Adult, subadult, juvenile	2000	3-24 m (10-80')
Batchawana, ON	Adult, juvenile	1997	6.1-30 m (20-100')
Black, ON	Adult	1996	—
Clark's Bay, ON	Juvenile	1997	—
Goulais, ON	Adult	1997	—
Michipicoten, ON	Adult	1997	—
Nipigon, ON	Adult	1997	—
Thunder, ON	Adult, juvenile	1997	—
Wawanagon Bay, ON	Juvenile	1997	—

APPENDIX C

Habitat in Lake Superior Tributaries Available for Lake Sturgeon and Associated Environmental Stresses

River	Natural Barrier (km)	Man-Made Barrier (km)	Life Stage Observed	Last Recorded Spawning	Current Stressors
Pigeon, MN/ON	3.1	—	Adult 1964	—	—
St. Louis, MN/WI	40	—	Juvenile	Early 1900s	Exotic species, loss of wetlands
Bad, WI	71	—	Adult, juvenile, larvae	1997	Sedimenta-tion
Ontonagon, MI	11-400	—	1 adult 1994	1800s	Erosion, loss of wetlands, regulated water flows, dredging in lower river
Sturgeon, MI	75	69	Adult, larvae juvenile	1997	Dam at 69 rkm, sediment loads, Otter Lake level control structure
Tahquamenon, MI	24	—	—	—	Sedimenta-tion, past logging practices, little spawning habitat

River	Natural Barrier (km)	Man-Made Barrier (km)	Life Stage Observed	Last Recorded Spawning	Current Stressors
Batchawana, ON	10	—	—	—	—
Big Pic, ON	100		Larvae	1995	
Black Sturgeon, ON		16.3	Adult	1996	Dam at 16.3 rkm, past logging
Goulais, ON	82	—	—	—	—
Gravel, ON	16.3		Adult	1985, 1988	—
Chippewa, ON	2.2	—			—
Kaministiquia, ON	47	—	Juvenile	1994, 1997	—
Michipicoten, ON	—	16.6	Adult	1997	Dam at 16.6 rkm, poaching, regulated water flows
Nipigon, ON	—	12.9	Adult	1996	Dam at 12.9 rkm, regulated water flows
White, ON	6		—	—	—
Wolf, ON	—	5.5 and 11.3	—	—	Dam at 11.3 rkm, low-head lamprey barrier at 5.5 rkm

MISCELLANEOUS PUBLICATIONS

February 1993	What's next? the prediction and management of exotic species in the Great Lakes (report of the 1991 workshop). E.L. Mills, J.H. Leach, C.L. Secor, and J.T. Carlton. 22 p.
August 1993	A survey of fish-community and habitat goals/objectives/targets and status in Great Lakes areas of concern. J.H. Hartig. 95 p.
August 1993	Toward integrating remedial-action and fishery-management planning in Great Lakes areas of concern. J.H. Hartig. 34 p.
September 1994	Walleye-rehabilitation guidelines for the Great Lakes area. P.J. Colby, C.A. Lewis, R.L. Eshenroder, R.C. Haas, L.J. Hushak. 112 p.
April 1996	A lake trout restoration plan for Lake Superior. M.J. Hansen [ED.]. 34 p.
August 1998	A lake trout rehabilitation guide for Lake Huron. M.P. Ebener [ED.]. 48 p.
May 2003-01	A rehabilitation plan for walleye populations and habitats in Lake Superior. M.H. Hoff [ED.]. 22 p.