Restoration of Declining Lake Sturgeon Populations: A Northern New York Case Study

Maria Hall, Emily Greer, and Melissa Fogarty
St. Lawrence University Biology Department
Canton, NY

Erika Barthelmes – Conservation Biology
Spring 2012
Executive Summary

Lake sturgeon (*Acipenser fulvescens*) are the largest freshwater fish in North America. These fish have existed for over 200 million years and have changed very little. In the early 1900s, lake sturgeon became extremely valuable as they provided caviar, meat, and other economically prized products. They are long-lived, slow maturing fish and overexploitation has diminished their population down to 1% of its original size. Despite the fact that commercial fishing was halted in the 1970s, populations in New York have failed to rebound. Habitat fragmentation caused primarily by dams constructed throughout Northern New York has prevented the few remaining reproducing adults from reaching critical spawning ground. In recent decades, there has been a significant push to restore lake sturgeon populations in New York, but progress has been slow.

This paper extensively reviews the ecology, historical overfishing, and current threats to lake sturgeon, and solutions to this conservation problem. There are numerous stakeholders interested in the recovery of lake strurgeon, including federal governments, hydropower companies, the Mohawk First Nation on the Akwesasne Reservation, scientists and recreational fishermen. We have contacted several people involved with current lake sturgeon projects in New York including members of the NYSDEC. Our research has helped to uncover potential, feasible, and best options for lake sturgeon recovery. While traditional hatcheries have been the primary management strategy for years, we deem a relatively new type of hatchery system known as streamside rearing facilities (SRFs) as the best way to increase populations. After examining the threats to biodiversity, different stakeholder perspectives, governmental issues, and existing conservation work, this report proposes a plan for increasing lake sturgeon
populations via SRFs, and concludes with a discussion of the step-by-step implementation of such facilities and the requirements needed to continue these projects for years to come.
Problem Definition

Lake sturgeon (*Acipenser fulvescens*) is a freshwater fish native to large river and lake systems throughout the northeastern and central United States as well as southeastern Canada.\(^1\) It is the largest freshwater fish in the United States, reaching approximately 7 feet long weighing over 200 pounds. Lake sturgeon complete their life cycle entirely in freshwater systems.\(^2,3\) Lake sturgeon have been swimming throughout these areas for over 200 million years, and the fish today are not unlike their ancestors from the Upper Cretaceous period.\(^4,5\) Like most *Acipenser* species, lake sturgeon are easily recognized by their scale-less bodies, which is instead covered by five rows of bony plates, known as scutes. The skull is heavily armored by plates and the swim bladder resembles lung-like characteristics of ancient bony fishes.\(^6\) Their mouth is located on the ventral portion of the head, and barbels are situated near the tip of the snout which are highly sensitive and used to detect prey. The position of the barbels is used to distinguish lake sturgeon from other sturgeon species.\(^7\)

Lake sturgeon are noted for their longevity. In Northern New York specifically, individual fish have been aged at over 97 years.\(^8\) Female fish do not reach sexual maturity until they are 20 or 30 years old, and once females reach this age, they can only spawn once every seven to nine years. On the other hand, males reach sexual maturity between the ages of 12 and 15, and spawn every one to three years.\(^9,10\) Young lake sturgeon experience a period of rapid

\(^1\) Trested and Isely, 2011  
\(^2\) Brooking et al. 2011  
\(^3\) McDermid et al. 2011  
\(^4\) Raloff, 2006  
\(^5\) Peterson and Vecsei, 2007  
\(^6\) IBID  
\(^7\) IBID  
\(^8\) Trested and Isely, 2011  
\(^9\) Adams et al. 2006
growth followed by a delay of maturation, and while this delay of maturation can set back reproduction, it provides the time and energy needed to maximize body size before a sturgeon’s first spawning event.\textsuperscript{11}

When lake sturgeon reach reproductive age, individuals migrate long distances from their resident lakes or rivers to rapidly moving waters with large benthic substrates to spawn such as gravel or limestone.\textsuperscript{12,13} Eggs must be deposited in fast moving water to prevent them from clumping and suffocating. Rapids also protect eggs from fungal infections.\textsuperscript{14} Currents are essential to spawning grounds by assisting in increased egg dispersal and decreasing predation.\textsuperscript{15} Spawning events are tightly correlated with water temperature and spawning typically takes place in the spring, from April to June, when the water temperature is between 10-15° C. Males arrive to spawning grounds before females, and when a female arrives, she is surrounded by a male who stimulates egg release by hitting her flanks. Studies have suggested that this polygamous mating strategy “guarantees the highest number of possible mates for both sexes, while minimizing the amount of energy expended in finding mates.”\textsuperscript{16}

Lake sturgeon’s feeding habits change as they mature. These opportunistic benthic feeders prey primarily on insect larvae, crustaceans, and mollusks.\textsuperscript{17} Prey items are detected using tactile, chemosensory, olfactory, and electrosensory receptors located on their barbels, and are sucked in by a quick expansion of the lake sturgeon’s protractible mouth.\textsuperscript{18} Juveniles have

\textsuperscript{10} Peterson and Vecsei, 2007  
\textsuperscript{11} IBID  
\textsuperscript{12} Boase et al. 2011  
\textsuperscript{13} Roseman et al. 2011  
\textsuperscript{14} McQuown et al. 2003  
\textsuperscript{15} Beamesderfer and Farr, 1997  
\textsuperscript{16} Peterson and Vecsei, 2007  
\textsuperscript{17} Nilo et al. 2006  
\textsuperscript{18} Peterson and Vecsei, 2007
highly diverse diets; insect larvae (Diptera, Trichoptera, and Ephemeroptera) are the main
components of young lake sturgeon diet in the St. Lawrence River, for example. These
organisms are found buried in soft sediment, and are key to the survival of small, newborn
sturgeon.\textsuperscript{19} Larger sturgeon (adults greater than 600 cm) consume mollusks, including invasive
zebra mussels (Dreissena polymorpha).\textsuperscript{20} For instance, in Oneida Lake, zebra mussels now
make up over 50\% of lake sturgeon diet.\textsuperscript{21}

The low lake sturgeon numbers seen today in New York is a result of the
overexploitation that occurred in the 1900s. Prior to 1860, lake sturgeon had no commercial
value, yet they were frequently killed by fishermen because they destroyed nets with their sharp,
bony plates.\textsuperscript{22} The U.S. was the largest exporter of black caviar (roe) in the 19th century,
shipping Atlantic sturgeon (A. oxyrinchus oxyrinchus) roe from the Hudson and Delaware Rivers
to Europe. By 1900 however, the Atlantic sturgeon population crashed, causing the caviar
industry to turn to lake sturgeon for export to Europe.\textsuperscript{23,24} Additionally, the lake sturgeon’s swim
bladders were used to make paint additives and isinglass, a form of collagen that is used to
clarify beer, glue, jellies, and other commercially important products.\textsuperscript{25} The lake sturgeon
became the most valuable commercial fish in North America by 1925.\textsuperscript{26}

Overexplotation activities facilitated habitat destruction and many spawning habitats in
major rivers were destroyed by pollution, shoreline development, and the construction of

\textsuperscript{19} Nilo et al. 2006
\textsuperscript{20} McCabe et al. 2006
\textsuperscript{21} Jackson et al. 2010
\textsuperscript{22} Hay-Chmielecki and Whelan, 1997
\textsuperscript{23} Pikitch et al. 2005
\textsuperscript{24} Peterson et al. 2007
\textsuperscript{25} IBID
\textsuperscript{26} IBID
One such problem that came with the development of shipping channels was the introduction of the invasive zebra mussel attached to cargo vessels. Zebra mussels invaded the St. Lawrence River in the 1980’s and have drastically altered the complexity of its benthic communities. Today, the Laurentian Great Lakes and sections of the Mississippi River have been compromised as well. Zebra mussels can colonize any substrate, from clay and rock to dock walls and outboard motors. These bivalves make benthic habitats more complex by changing the structure of the food web, altering the substrates on which they are found, and by filtering microorganisms and silt out of the water. The introduced mussels are hampering efforts to reestablish lake sturgeon populations. While adult sturgeon can feed on zebra mussels, hatchery-raised juveniles cannot. Because most released fingerlings are only between two and 12 inches long, they cannot adequately feed on zebra mussels that dominate the food chain. Zebra mussels also remove the habitat usually occupied by chironmids, a family of flies that resemble mosquitos, seriously impeding foraging success and facilitating the premature mortality of sturgeon juveniles. Without lake sturgeon to effectively manage zebra mussels in the St. Lawrence River, the biodiversity of northeastern riparian systems is threatened.

Overexploitation and habitat alteration in the form of shipping channels that likely facilitated the introduction of the zebra mussel, all led to massive population declines throughout North America such that lake sturgeon harvest in Lake Erie dropped 80%, from 2.3 million kilograms in 1860 to 0.45 million kilograms in 1905. In the 1930s, the lake sturgeon had

27 Roseman et al. 2011
28 McCabe et al. 2006
29 Beekey et al. 2004
30 MacIsaac, 1996
31 Beekey et al. 2004
32 McCabe et al. 2006
33 MacIsaac, 1996
34 McCabe, 2006
disappeared completely from commercial catches, leading to a ban throughout the Great Lakes region, five years after it was named the most valuable fish in North America.35 The New York lake sturgeon fishery officially closed in 1976.36

Today, zebra mussels continue to be an issue as well as several other obstacles that threaten already low population numbers including dams, loss of genetic diversity, and exposure to environmental toxins.

Dams negatively influence populations via habitat fragmentation which influences water morphology and hydraulics. Each of these effects of dams also effects lake sturgeon spawning. Introduction of a dam to a river system is argued as “the most severe problem…lake sturgeon populations could face.”37 The dam of primary concern to this report is the Moses-Saunders dam on the St. Lawrence River in Massena. However, the Massena Electric Department proposed a new hydroelectric dam to replace the one that breached in 1997 on the Grasse River. The plan fell through when Massena Electric pulled out in the summer of 2010, citing a lack of cooperation from state and regulatory agencies.38 Mayor James F. Hindy has been pushing for repairs to the weir and a preliminary design has been created. A weir is a barrier that is created to manage water around developed areas, not for power generation. It is not clear where the project stands as the village of Massena is only in the beginning stages of addressing important issues such as changes in the ecosystem since the weir breached 15 years ago.39 This project will need to be monitored as it progresses because it is uncertain how lake sturgeon populations will respond to the presence of another barrier along the Grasse River.

35 Peterson et al. 2007
36 Brooking et al. 2010
37 Mailhot et al. 2011
38 Hayden, 2012
39 IBID
Dams have several negative effects as will be described. Dams degrade habitat via loss and fragmentation. Habitat fragmentation created by dams comes in two major forms: the elimination of flood areas and the destruction of the natural drop of rivers. Hydroelectric dams are often constructed in the natural drop area because of the potential to create a driving force which raises the water level, which is beneficial for power generation.\textsuperscript{40} However, studies have shown that natural drop areas are ideal lake sturgeon spawning habitat.\textsuperscript{41}

Second, dams create habitat fragmentation by changing upstream and downstream abiotic factors such as flow, turbidity, and temperature as well as biotic factors such as migration of lake sturgeon.\textsuperscript{42,43} Upstream and downstream dynamics play a significant role in the lake sturgeon life cycle and it has been found that lake sturgeon in the St. Lawrence River are spread along a size gradient such that young sturgeon are located downstream and the older lake sturgeon are seen upstream.\textsuperscript{44} Upstream migration is often exhibited in sexually mature lake sturgeon who travel upstream in search of spawning ground close to rapids and cooler water temperatures. Thus, for the St. Lawrence River it may be assumed that upstream river dynamics hold important spawning habitat from where the eggs drift downstream.

A third habitat fragmentation consequence of dams is the construction of roads and bridges, which in turn increase access to waterways. Negative factors associated with dam access roads and bridges range from removal and/or loss of riparian vegetation, deterioration of aquatic habitat and channel stability, and increased toxic runoff into the water.\textsuperscript{45}

\textsuperscript{40} Ontario Waterpower Association, 2009
\textsuperscript{41} Friday, 2008
\textsuperscript{42} Breining, 2003
\textsuperscript{43} Auer, 1999
\textsuperscript{44} Mailhot et al. 2011
\textsuperscript{45} Ontario Waterpower Association, 2009
Fourth, dams influence lake sturgeon populations via water levels. Hydroelectric dams have two major operating modes that determine flow regime, the rate at which water is released from the dam.\(^{46}\) The first major mode is peak flow: the upstream flow of water is not equal to the downstream flow of water that was released from the dam. The effects of dam operations on lake sturgeon can be seen when comparing peak flows to the second major mode, run of the river (ROR). The ROR mode varies distinctly from peak mode because the upstream to downstream flow of the river are equal. Thus, ROR mode limits the effect dams have on the natural flow regime of the waterway.\(^{47}\) It was found that ROR increased five characteristics of spawning lake sturgeon populations: 1) spawning sturgeon spend less time at spawning sites, allowing them to return to areas with protective cover and food, 2) the total number of lake sturgeon increased from 71-79 during peak to 103-121 during times of ROR, 3) the number of sturgeon females on site increased from 13% to 39% in peak to ROR, 4) sturgeons captured during ROR mode were larger and weighted significantly more, and 5) the number of ripe-running sturgeon increased.\(^{48}\) These findings indicate that the altered flow regime of the waterway can either positively or negatively impact lake sturgeon populations depending on what operational mode is used. Clearly, ROR has beneficial affects on sturgeon populations due to the fact that the flow regime is kept as natural as possible within the presence of dams. Unlike ROR, peak flow completely alters the flow regime of the waterway and negatively impacts lake sturgeon spawning and population size.\(^{49}\) While it is clear that peak flow is more common and yet ROR is better for lake sturgeon, it is uncertain what type of operational mode the Moses-Saunders dam at Massena employs.

---

46 North Bank Tunnel Concept Flow Regime, December 2006
47 http://www.dnr.state.mn.us
48 Auer, 1996
49 IBID
An additional major effect of dams on lake sturgeon populations is related to water morphology and hydraulics. Water hydraulics refers to the effect of variation within water temperature, water levels, and flow regime, and their overall implications on the dynamics of the waters natural system. The most direct effect of dams on water temperature is dependent upon where water is being drawn from within the water column. Lake sturgeon have been found to be extremely sensitive to water temperature particularly during spawning when ideal temperatures range from approximately 13-18 degrees Celsius.\(^{50}\)

Loss of genetic diversity is another critical threat to lake sturgeon populations and in order to help facilitate the recovery of a species, it is critical to know about genetic diversity and potentially useful sub-populations to maintain species vitality.\(^{51}\) Genetic studies have provided information about population structure, gene flow, and genetic diversity among different populations, all of which offer conservationists the necessary information to make sound management decisions.\(^{52}\) In the last decade, genetic studies have been enhanced with the development of microsatellites and mitochondrial DNA (mtDNA), which have been used to estimate lake sturgeon population diversity.\(^{53,54,55}\)

Recent studies examining mtDNA have demonstrated that lake sturgeon found in the Great Lakes, Hudson Bay drainage area, and the St. Lawrence River are genetically distinct. Seven different lake sturgeon populations are located within each geographic region.\(^{56}\) These divergent groups are genetically different because of separate glacial ancestry. During the last ice

\(^{50}\) McKinley et al. 1997  
\(^{51}\) Hay-Chmielewski and Whelan, 1997  
\(^{52}\) DeHaan et al. 2006  
\(^{53}\) McQuown et al. 2003  
\(^{54}\) DeHaan et al. 2006  
\(^{55}\) McDermid et al. 2011  
\(^{56}\) McQuown et al. 2003
age, two genetically distinct lake sturgeon populations survived in two refugia located in the Mississippian region and in the Missourian region. Lake sturgeon in the Ottawa and St. Lawrence Rivers have Mississippi ancestry, while Great Lakes and Hudson Bay lake sturgeon have Missourian ancestry. Observed heterozygosity and allelic richness is relatively similar between Northern Ontario populations and populations in the Great Lakes basin.57

Low levels of mtDNA variability have been reported for populations throughout North America as collections from the St. Lawrence River and Great Lakes drainages expressed a single haplotype, and lake sturgeon from Hudson Bay drainages displayed the same haplotype, plus one additional haplotype.58 Microsatellite data from sturgeon in the Great Lakes basin demonstrated an average allelic richness of 3.11 while observed heterozygosity in the Great Lakes basin is 0.61.59 In the Hudson bay drainages, allelic richness among lake sturgeon is 2.72 and observed heterozygosity is 0.482.60 A study of St. Lawrence River lake sturgeon revealed that allelic richness is 3.43 and average heterozygosity is 0.563.61 The importance of these statistics is that they illustrate the genetic differences in these three regions; lake sturgeon in the St. Lawrence River and its tributaries have more variations of genes compared to the other populations.

Heterozygosity is an important characteristic to note because heterozygous individuals generally have better fitness than individuals that are homozygous. Approximately 56% of lake sturgeon in the St. Lawrence River are heterozygotes, while 61% of lake sturgeon in the Great Lakes are heterozygotes. Only 48% of the lake sturgeon in the Hudson Bay drainage are

57 McDermid et al. 2011
58 McQuown et al. 2003
59 DeHaan et al. 2006
60 McDermid et al. 2011
61 McQuown et al. 2003
heterozygotes. According to DeHann et. al. (2006), overfishing in the early 1900s caused a significant reduction in lake sturgeon numbers, however this did not cause a serious loss of genetic diversity. The longevity of this species might be the reason why significant genetic diversity was maintained. Maintenance of genetic diversity does not appear to be the case in the St. Lawrence River populations as habitat fragmentation is preventing individuals from perpetuating their genetic information. Overall, sturgeon in the Great Lakes contain relatively healthy genetics, while fish in the St. Lawrence and Hudson Bay populations require more protection to maintain and increase genetic variability.

Anthropogenic factors also play a key role in lake sturgeon genetics. Lake sturgeon of the St. Lawrence River have experienced a bottle neck due to heavy hunting, but habitat fragmentation negatively impacts gene flow too. Lake sturgeon are a highly migratory species, and the vast number of canals and dams prevent lake sturgeon within the St. Lawrence river and its tributaries from migrating to spawning areas. These barriers increase the risk of inbreeding. Part of the reason why lake sturgeon populations in the Great Lakes region are more genetically variable than other populations is because there are no barriers preventing these populations from freely moving long distances. While lake sturgeon in the Great Lakes region suffered the same overharvesting as population in the St. Lawrence and its drainages, the habitat is not fragmented, allowing lake sturgeon in this zone to maintain genetic diversity.

Environmental toxins threaten sturgeon populations, and methylmercury is the major toxin of concern. Methylmercury levels increase as a response to flooding, anaerobic bacterial activity, copious levels of available organic matter, and abiotic parameters such as pH and  

---

62 DeHann et al. 2006  
63 McDermid et al. 2011  
64 McQuown et al. 2003  
65 DeHaan et al. 2006
dissolved oxygen levels in the water.\textsuperscript{66} Toxins are related to the issue of dams. Reservoirs have been shown to contain increased levels of methylmercury because it is being contained for an undetermined amount of time and the original water source can be combined with other sources of varying water quality, depending on the duration within a reservoir.\textsuperscript{67} Contamination of lake sturgeon varies by their size with higher concentrations seen as length increases, yet researchers have found that mercury did not affect growth rate, the only physiological parameter tested in this study.\textsuperscript{68} Growth rate has been the only physiological parameter of lake sturgeon that has been well examined and this is an area where more research is needed to fully understand the effect of toxins on this long-lived fish. Bioaccumulation is a major area of concern with lake sturgeon because they are benthic feeders and toxins have been found to decrease plankton and benthos biomass.\textsuperscript{69} Therefore, it is inevitable that toxins negatively affect aquatic ecosystems on a large scale by affecting both predator and prey.

Stakeholders

A stakeholder is an individual or a group that has vested interests in a certain issue. In regards to lake sturgeon, many stakeholders have been identified ranging from governmental institutions to scientists. A description of the stakeholder and their relation to low lake sturgeon populations are described below.

Both the United States and Canadian governments have a stake in declining lake sturgeon populations. The government is responsible for implementing and upholding policies regarding threatened species. The New York state Department of Environmental Conservation (NYSDEC)

\textsuperscript{66} Hydro-Quebec, 2001
\textsuperscript{67} Ontario Waterpower Association, 2009
\textsuperscript{68} Haxton and Findlay, 2008
\textsuperscript{69} Billard and Lecointre, 2001
also has a stake as their mission explicitly states: “protecting New York State's environment and managing natural resources.” 70 In addition, the Mohawk Nation of Akwesasne is a third governmental body involved in the lake sturgeon problem. These three entities will be addressed separately below.

Another major stakeholder is the Mohawk Nation of Akwesasne located along the St. Lawrence River. Akwesasne historically have consumed lake sturgeon and continue to do so today. There is some concern about how much sturgeon is being consumed as the population is small, and sturgeon are benthic fish that contain mercury in their flesh. As a traditional consumer, the Akwesasne hold a high responsibility to protect sturgeon populations for their cultural significance, as well as to maintain proper catch levels that are dependent on the sturgeon’s population viability.

The Akwesasne reservation has been an active participant in lake sturgeon restoration efforts. The Mohawk Tribe recently received funding for a three-year lake sturgeon restoration project funded by the Great Lakes Restoration Initiative (GLRI). This plan will focus on habitat loss, degradation of lake sturgeon population, and restrictions regarding sturgeon consumption within the St. Lawrence River Watershed. Such a restoration project will be extremely beneficial by increasing the available literature and augmenting knowledge regarding lake sturgeon in New York. The Saint Regis Mohawk Tribes Environmental Division was contacted during the course of this study with the hopes of learning more about their Lake Sturgeon Restoration Plan, the cultural and historical role of lake sturgeon within the community, and feedback on their views of the lake sturgeon problem as direct stakeholders in the issue. Unfortunately, little contact was made, and thus little was learned regarding the Tribes’ role as a stakeholder.

70 www.dec.ny.gov
An additional major stakeholder in the lake sturgeon problem are power companies. The New York Power Authority (NYPA) runs the Moses-Saunders dam on the St. Lawrence River and Brookfield Power runs 27 hydroelectric plants on the Raquette River.\textsuperscript{71} Both possess significant influence in determining the overall environmental conditions and applications the hydroelectric facilities have on aquatic ecosystems. The health of aquatic habitats would potentially improve greatly if hydropower corporations made more environmentally conscious decisions. For example, dams themselves would be more ecologically sound if operated under the more natural flow regime of ROR. Both NYPA and Brooksfield Power have environmental stewardship information on their websites and both strongly emphasize the fact that they uphold and are willing to meet all environmental laws and regulations.\textsuperscript{72,73}

Hydropower companies are the major benefactors from hydroelectric facilities and in some instances they have used the profits they are reaping to positively give back to the environment. One example of this is Hydro-Quebec. This company compensation for the natural resources that they had altered with the construction of dams by creating spawning sites for lake sturgeon and other threatened aquatic species.\textsuperscript{74} The NYPA is the largest publicly owned power company in the nation, and they too have allocated funds and resources to the betterment of the natural environments that their hydroelectric facilities are impacting. For example, the NYPA contributed $11 million to habitat improvement projects (HIPs). One major HIP occurred in the North Country where spawning beds were created in the St. Lawrence River for lake sturgeon. Another HIP resulted in eel ladders at the Mose-Saunders Dam, which brought numerous awards and prestige to the NYPA as they worked to restore the environment.

\textsuperscript{71} http://www.absolutelybusiness.com/
\textsuperscript{72} http://brookfieldrenewable.com
\textsuperscript{73} http://www.nypa.gov/
\textsuperscript{74} http://hydroforthefuture.com/
Scientists and researchers are also stakeholders in the recovery of lake sturgeon in the North Country. These fish have been around for over 200 million years and are a living link to the past, a unique species that can provide the scientific community with information about the biological and geographic evolution of this area.

Lastly, recreational fishermen have a stake in this issue. Sport angling is a very popular pastime in the United States and freshwater sport fishing generates approximately $38 billion annually through the purchase of tackle, permits, apparel, and lodges.\textsuperscript{75} Canada and Michigan still maintain a catch-and-release lake sturgeon fishing season in specific water bodies, with permits that only allow one fish per year.\textsuperscript{76} The presence of lake sturgeon in Northern New York could certainly attract anglers to the area. American Fisheries Society member Web Pearsall states that “midway through last year we were getting reports of catches of sturgeon on a regular basis.”\textsuperscript{77} Fisheries manager of region eight of the NYSDEC also reports that “the vast, vast majority [of lake sturgeon] were caught and released and people would call us and let us know. But we also got some reports of people saying, ‘Gee, I saw a guy last week keep one.’ We just want to get the word out that these are a special fish and if you do catch one, please release it as soon as you possibly can.”\textsuperscript{78} With more people fishing, the DEC issued these sturgeon release guidelines: 1) avoid bringing the fish into a boat or onto shore, instead using pliers to remove the hook while it's still in the water 2) if snapping a picture, support the fish horizontally, never hold a sturgeon vertically by the head, gills or tail and 3) avoid touching their eyes and gills.\textsuperscript{79}

Fishermen rely on well-functioning freshwater ecosystems with healthy populations of fish, and

\textsuperscript{75} Danylchuk and Cooke, 2010
\textsuperscript{76} Roseman et al. 2011
\textsuperscript{77} Rassam, 2011
\textsuperscript{78} IBID
\textsuperscript{79} IBID
renewed populations of lake sturgeon in Northern New York could help to fuel local economies through sport fishing.

**Governmental Issues**

Every conservation issue is framed within legal parameters. Governmental and regulatory bodies create environmental laws and processes, and while they are not always upheld, they are ultimately designed to protect and sustain wildlife and natural resources. Wildlife clearly do not follow political boundaries and therefore communication and cooperation between different nations is inevitable regarding those species whose ranges traverse political boundaries. The Canadian perspective will be addressed first, followed by the United States perspective and then a synthesis of how the two governmental and regulatory bodies are working together in the name of lake sturgeon restoration.

The constitutional monarchy of Canada established the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1997 and this governmental body arose due to the need for a single, official, and scientifically sound national classification of wildlife species at risk of extinction. COSEWIC is established under section 14 (1) of the federal Species at Risk Act (SARA) and its assessments form the basis for the list of wildlife species at risk under that legislation. All wildlife species whose ranges extend into Canada, such as the lake sturgeon, are part of COSEWIC’s jurisdiction and their level of extinction may be evaluated by COSEWIC. The committee’s mission is:

“Determin[ing] the national status of wild Canadian species, subspecies, varieties, or other designatable units that are suspected of being at risk of extinction or extirpation. COSEWIC uses a process based on science and Aboriginal or community knowledge to assess wildlife species at risk. All native mammals, birds, reptiles, amphibians, fish,

---

80 www.cosewic.gc.ca This was the primary source of information on the Canada section came from this website.
arthropods, mollusks, vascular plants, mosses and lichens are included in the COSEWIC’s current mandate…In all of its actions, COSEWIC uses the best available information relevant to assessing wildlife species’ risk which it may obtain from any credible sources of knowledge or the wildlife species and its habitat.81

The first step in COSEWIC’s task is to choose, from among the thousands of wildlife species in Canada, which ones may be the most at risk of extinction or extirpation, and are therefore candidates for more detailed assessment through a COSEWIC status report. Candidate wildlife species are those that have been identified by the subcommittees that make up COSEWIC; the Species Specialist subcommittee (SSC) and Aboriginal Traditional Knowledge subcommittee (ATK SC). Each SSC annually prepares and maintains a SSC candidate list of wildlife species that it considers in danger of extinction.

The second step is that each candidate species is evaluated for eligibility for COSEWIC assessment. Species must meet a certain number of criteria regarding taxonomic validity, native origin, regularity of occurrence, and dependence on Canadian habitat to be eligible. The initial assessment of species eligibility is completed by the SSC Co-chairs and their members. Eligibility is then reviewed and confirmed by COSEWIC.

Third, with a list of eligible species now in hand, the COSEWIC works to filter that list even more. Eligible candidate species are prioritized and placed on SSC candidate lists using a coarse filter system, a system that “blends levels of apparent risk with considerations of taxonomic distinctiveness, global distribution, and proportion of range within Canada.”82 In other words, each SSC will assign their candidate species into one of three priority groups: Group 1 are species that have the highest priority for COSEWIC assessment, while Groups 2 and 3 are species that have medium and lower priority, respectively, for COSEWIC assessment. It is

81 IBID
82 IBID
important to note that only biological factors are used to prioritize wildlife. Fourth, highest priority species from the SSC candidate lists will be reviewed and ranked by COSEWIC, resulting in the COSEWIC Candidate List. At this stage, the COSEWIC bases its rankings on prioritization data submitted by each SSC. The COSEWIC Candidate List therefore identifies the highest priority candidate wildlife species for which status reports are desirable.

Formulation of status reports are the next step and they summarize information that is the basis for status determinations, each report is an “up-to-date compilation and analysis of all relevant, available, and credible biological information concerning a wildlife species and its status in Canada.”83 This information must include distribution, extent of occurrence, area of occupancy, abundance, population and habitat trends, and factors of threats limiting a species. A draft status report is passed on to the SSC Co-chairs and once it has been read and approved at this level, it is further passed down to all SSC members. Comments and suggestions are sent to the SSC Co-chair and forwarded to the writer with instructions for changes that must be incorporated into the report. The result is the Interim Status Report. This report is sent by the SSC Co-chairs to SSC members and any other relevant regulatory bodies for final review at least six months before a Wildlife Species Assessment meeting. Any final changes that need to made to the report must be made at least two months before the Assessment meeting.84 At this stage, reports include status recommendations from the SSC. Any new information or data that is significant to the designation of the wildlife species may be presented at the Wildlife Species Assessment Meeting in written form and the COSEWIC may defer consideration until a subsequent meeting or proceed with the assessment, incorporating the new information. It is the job of the SSC Co-chairs to ensure that the final status designation, and any revisions approved

83 IBID
84 IBID
by the COSEWIC at the meeting, are incorporated into the Interim Status Report. A final, clean copy of the report is provided by the SSC Co-chair to the Secretariat who then adds a summary of the COSEWIC assessment, ultimately producing the COSEWIC Assessment and Status report that is available on the SARA public registry soon after the meeting.85

For each species considered at a meeting, COSEWIC considers the following five items sequentially to determine a status designation:

1. Is there sufficient information presented in the report to determine wildlife species eligibility?
2. Given sufficient information, is the wildlife species eligible for assessment?
3. Is the status report adequate and acceptable for assessment purposes?
4. What status is suggested by application of approved COSEWIC quantitative assessment criteria and guidelines?
5. Does the suggested status conform to the COSEWIC definition for the proposed status category.

Is there sufficient information presented in the report to determine wildlife species eligibility?

If it is evident that that there is not enough information to determine eligibility for assessment, the report will be either rejected because necessary information was not included or a finding of data deficient will be considered because relevant information is considered.

Given sufficient information, is the wildlife species eligible for assessment?

If given sufficient information, the SSC Co-chair establishes eligibility for COSEWIC assessment using the given criteria of taxonomic validity, native wildlife species and regularity of occurrence. The COSEWIC may choose to 1) accept the SSC’s recommendation for eligibility of wildlife species, 2) alter the parameters of the species under consideration or 3) return the report to the SSC as ineligible for assessment.

85 IBID
Is the status report adequate and acceptable for assessment purposes?

Once it has been determined that the wildlife species is eligible for assessment, the SSC Co-chair will summarize the report and present the rationale for the status recommendation. After discussion, committee members may let the report stand for status assessment or defer it for further work. Assessment of species are typically only deferred if the report did not include relevant, currently available knowledge, information, or data, or did not present an objective analysis of the information.

What status is suggested by application of approved COSEWIC quantitative assessment criteria and guidelines?

Once the status report has been accepted, the Committee discusses the appropriate status designation. At this stage, information in the status report is used to review the wildlife species according to the quantitative COSEWIC criteria. The quantitative criteria include decline in the total number of mature individuals, small distribution range and decline or fluctuation, small and declining number of male individuals and very small or restricted total population.\(^{86}\)

Does the suggested status conform to the COSEWIC definition for the proposed status category?

The discussion is concluded by the SSC Co-chair reviewing the assessment criteria and suggesting a status category. Finally, the Committee considers all the information and evaluates if the status category suggested by the application of the criteria and guidelines is consistent with the definition of the status category used by COSEWIC. If consistencies exist, the status representing the most appropriate definition will be used. COSEWIC status categories are:

\(^{86}\)IBID
<table>
<thead>
<tr>
<th>Status Category</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extinct (X)</td>
<td>A wildlife species that no longer exists</td>
</tr>
<tr>
<td>Extirpated (XT)</td>
<td>A wildlife species that no longer exists in the wild in Canada, but exists elsewhere</td>
</tr>
<tr>
<td>Endangered (E)</td>
<td>A wildlife species facing imminent extirpation or extinction</td>
</tr>
<tr>
<td>Threatened (T)</td>
<td>A wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction</td>
</tr>
<tr>
<td>Special Concern (SC)</td>
<td>A wildlife species that may become Threatened or endangered because of a combination of biological characteristics and identified threats</td>
</tr>
<tr>
<td>Data Deficient (DD)</td>
<td>A category that applies when the available information is insufficient (a) to resolve a wildlife species' eligibility for assessment or (b) to permit an assessment of the wildlife species' risk of extinction</td>
</tr>
<tr>
<td>Not At Risk (NAR)</td>
<td>A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances</td>
</tr>
</tbody>
</table>

Table 1. COSEWIC status categories with explanations for when each would be used.

In 2003, the Species at Risk Act (SARA) was proclaimed with the purpose of protecting wildlife species at risk in Canada and COSEWIC acts within the larger umbrella of SARA. Under SARA, the government of Canada will take COSEWIC’s designations into consideration when formulating the legal list of wildlife species at risk. Usually in late summer or early fall, the COSEWIC forwards its assessments to the Minister of the Environment and this begins the government’s consideration of the wildlife species for legal listing. Assessments of the COSEWIC are not automatically legal because under SARA, it is up to the federal government, a politically accountable body, to legally protect species that have been assessed by COSEWIC (QandA).
SARA separates the scientific assessment process from the listing decision. This approach ensures that scientists can provide fully independent recommendations, and that decisions affecting Canadians are made by elected officials who can be held accountable for those decisions.

COSEWIC uses the best biological information on a species deemed to be in some danger of disappearing from Canada to assess the risk status of that species. It reviews research information on population and habitat status, trends, and threats; uses community and Aboriginal traditional knowledge; and applies assessment criteria based on international standards.

COSEWIC assesses the species as extinct, extirpated, endangered, threatened, special concern, data deficient, or not at risk.

COSEWIC sends its assessment and supporting evidence (i.e., rationale and status reports) for species classified as at risk (Extirpated, Endangered, Threatened, or Special Concern) to the Minister of the Environment and the Canadian Endangered Species Conservation Council once per year. The COSEWIC assessment and the reasons for it are also posted on the SARA Public Registry.

The Minister of the Environment has 90 days in which to publish Response Statements on the Public Registry.

These statements indicate how the Minister intends to respond to each COSEWIC assessment and, to the extent possible, provide timelines for action. Certain species may require extended consultation.

The GIC within nine months after receiving the assessment may, on the recommendation of the Minister, by order:

a) accept the assessment and add the species to the List;
b) decide not to add the species to the List; or
c) refer the matter back to COSEWIC for further information or consideration.

If the GIC does not make a decision within nine months of receiving the COSEWIC assessment, the Minister shall by order amend the List according to COSEWIC’s assessment.

Once a species is added to Schedule 1, it benefits from all the legal protection afforded, and the mandatory recovery planning required, under SARA.

Figure 1. Listing a species under SARA.87

It is important to note that if the proposed designation by the SSC Co-chair is for a designatable unit below the species level i.e. subspecies, a justification for this must be presented following particular guidelines. The conservation of biological diversity requires protection for entities below the species level and within the Canadian government, they are referred to as

87 http://www.sararegistry.gc.ca/
Designatable Units (DUs). Guidelines to assist in the identification of DUs are for the purpose of status assessment by COSEWIC. The first step in identifying DUs is to evaluate whether a population or group of populations is discrete from other populations. There are several criteria that must be met to measure whether a populations may be considered discrete. Those criteria include but are not limited to evidence of genetic distinctiveness, natural disjunction between substantial portions of the species’ geographic range, and occupation of differing eco-geographic regions that are relevant to the species and reflect historical or genetic distinction. If a populations is considered discrete based on the above criteria, then the next step is to consider significance. Again, a population’s evolutionary significance may be gauged on several criteria; 1) evidence that the discrete population or group of populations differs markedly from others in genetic characteristics thought to reflect relatively deep intraspecific phylogenetic divergence, 2) persistence of the discrete population in an ecological setting unusual or unique to the species, and 3) evidence that the loss of the discrete population or group of populations would result in an extensive gap in the range of the species in Canada.

Fisheries and Oceans Canada, also called the Department of Fisheries (DFO), is the department within the Canadian government that is responsible for developing and implementing policies and programs in support of Canada's scientific interests in oceans and inland waters. The vision of the department is “excellence in service to Canadians to ensure the sustainable development and safe use of Canadian waters.” The federal government is constitutionally mandated to conserve and protect fisheries resources, yet the DFO works toward conservation and protection of inland freshwater fisheries, such as on the Great Lakes. To better address conservation needs, the department has a large science branch, with research institutions in
locations across the country. Major legislation under this department includes the Fisheries Act, which is applicable to lake sturgeon. The Fisheries Act is federal legislation established to manage and protect Canada's fisheries resources. It applies to all fishing zones, territorial seas and inland waters of Canada and is binding to federal, provincial and territorial governments. Additionally, when the species is found within national parks of Canada or other lands that are administered by the Parks Canada Agency, the species is protected and managed under the Canada National Parks Act or through tools available to the agency under other legislation.

Lake sturgeon were considered a single unit and designated “Not at Risk” in April 1986. The species was then split into separate designatable units (DU) in May 2005 and the unit of most importance to this report, the Great Lakes-Upper St. Lawrence DU8, was designated as Special Concern. This status was re-examined and changed to Threatened in November of 2006. The Minister of the Environment issued a response statement in December of 2007 regarding the Great Lakes-Upper St. Lawrence DU8 population of lake sturgeon; response statements are the Minister’s indication of how he intends to respond to COSEWIC’s assessments. Reasons for the Threatened status designation as outlined on the response statement indicate that a large commercial fishery existed in the Great Lakes during the mid-1800’s and early 1900’s at which time lake sturgeon populations were reduced to a small fraction of their original size, and appear to still be at very low levels. Additionally, the direct and indirect effects of dams and contaminants threaten lake sturgeon populations. The Minister of the Environment intends to respond to COSEWIC’s assessment by undertaking consultations with “the governments of Ontario and Quebec, Aboriginal peoples, stakeholders, and the public on whether or not the lake sturgeon Great Lakes-Upper St. Lawrence population should be added to the List of Wildlife

90 www.cosewic.gc.ca
Species at Risk (Schedule 1) under SARA.”  

Schedule one is the official list of wildlife species at risk and right now, the DU8 population has a Threatened status under COSEWIC and no status under SARA.

Switching sides, the United States approach to wildlife protection will be described as well as how lake sturgeon fit into the governmental management scheme. The International Union for the Conservation of Nature (IUCN) is the largest professional global conservation network and a neutral forum for governments and other organizations to work together to find pragmatic solutions to conservation challenges. Many departments of the U.S. government are a part of the IUCN including the U.S Fish and Wildlife Service under the Department of the Interior. The IUCN is run by a council elected by member organizations every four years at the IUCN World Conservation Congress. The IUCN Red List of Threatened Species is the world's most comprehensive inventory of the global conservation status of biological species. The Red List is set upon precise criteria to evaluate the extinction risk of thousands of species and subspecies.

Classifying a species under the IUCN is a lengthy and involved process and the fish was first assessed by the IUCN SSC Sturgeon Specialist Group in 1996 as Vulnerable. A more detailed look resulted in it being downgraded to Least Concern. The IUCN aims to have the category of every species re-evaluated every five years if possible, or at least every ten years. This re-evaluation process is done in a peer reviewed manner through IUCN Species Survival Commission (SSC) Specialist Groups, which are Red List Authorities responsible for a species, group of species, or specific geographic area. The map below illustrates the lake sturgeon’s range and provides an understanding as to why this fish has a status designation of least concern.

---

91 www.cosewic.gc.ca
92 www.iucn.org
According to the IUCN website, the lake sturgeon occupies large parts of United States and Canadian waters and the largest proportion of the global population lies in the Great Lakes and the St. Lawrence River basin. In the Great Lakes/St. Lawrence River basin, numerous management and recovery plans are in place among and between states and provinces sharing boundary waters. Their goals include conservation, rehabilitation and enhancement of sturgeon populations, completion of status assessments, identification and restoration of critical habitats, and elimination of the negative effects of dams. Most threats in the Great Lakes/St. Lawrence basin such as dams are well understood as described above and the IUCN feels that necessary conservation measures are being implemented and that most segments of the stock appear to be

---

93 Scott and Crossman, 1973
94 CITES, 2000
increasing (IUCN). Based upon all the data that has been collected regarding lake sturgeon and IUCN definitions, the IUCN concludes that the species currently is not facing a threat to its survival and is therefore categorized as Least Concern. The IUCN defines Least Concern as “a taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.”

![Figure 3. Structure of the IUCN Red List Categories.](http://intranet.iucn.org/)

Lake sturgeon are protected under the Convention on International Trade in Endangered Species (CITES) and require permits for international export and import. CITES is a multilateral treaty, with its main aim of assurance that international trade in specimens of wild animals and plants does not threaten the survival of the species in the wild, and it accords varying degrees of

---

95 ICUN GUIDELINES
96 http://intranet.iucn.org/
protection to more than 33,000 species of animals and plants. CITES is one of the largest conservation agreements in existence. Participation is voluntary, and countries that have agreed are known as Parties. Although CITES is legally binding on the Parties, it does not take the place of national laws, rather it provides a framework respected by each Party, which must adopt their own domestic legislation to implement CITES at the national level. The U.S. federal government is responsible for implementing CITES. Concern over increasingly large international trade of sturgeon products and declining sturgeon populations globally led to the listing of all previously unlisted sturgeon species under CITES Appendix II in 1998. This Appendix listing, that includes lake sturgeon in the Great Lakes, “means that international trade is allowed, but it is regulated by permits.”

The Endangered Species Act (ESA) is one of the most far reaching wildlife conservation laws ever enacted. The United States Fish and Wildlife Service in conjunction with the National Marine Fisheries Service and other federal and state agencies work together to prevent extinctions. Although the lake sturgeon is not listed under the ESA it deserves attention because it is an excellent piece of U.S. federal legislation that serves to conserve endangered and threatened species and the ecosystems on which they depend.

In New York specifically, lake sturgeon are a threatened species under state regulations, 6NYCRR Part 182. They are only a species of concern at the federal level, so no federal protection per se, however, since they are protected in several states, taking and transporting them illegally from one state to another is subject to the Lacey Act, as described by Ms. Lisa Holst, the Rare Fish Unit Leader at the New York State’s Department of Environmental Protection.

97 www.cites.org
98 Holst, 2012 Personal Communication
Conservation Albany office. The Lacey Act is a conservation law in the U.S. that was enacted in 1900. It protects both plants and wildlife by creating civil and criminal penalties for a wide array of violations, and most importantly prohibits trade in wildlife, fish, and plants that have been illegally taken, transported or sold. The law is still in effect, though it has been amended several times.

According to Ms. Holst, there is efficient communication between the U.S. and Canadian counterparts involved in lake sturgeon restoration efforts. The NYSDEC has not used eggs from the site in Quebec on the Riviere des Prairies since the mid-1990s and at that time, many of the current regulations did not exist, so the procedure was relatively simple. However, the process now involves permission from the Canadian provincial and federal governments, Canada issuing a permit to the U.S. in order to take the eggs, and the involvement of the U.S. Fish and Wildlife Service. There are many moving parts that require efficient interchange between the two nations. Ms. Holst also reports that the NYSDEC speaks to their Canadian counterparts through both formal and informal channels. New York participates in the Great Lakes Program which is multi-state on the U.S. side, multi-province on the Canadian side, and clearly international. On the U.S. side, the U.S. Fish and Wildlife Service, EPA, U.S. Geological Survey, plus several state agencies within New York and the Great Lakes states are involved. Furthermore, the Great Lakes Fisheries Commission is the entity that creates the disease testing protocols the DEC follows when they import eggs because prior to stocking the eggs have to be tested for a panel of standard fish diseases. DEC staff in the Watertown office and the Cape Vincent Fisheries Station are reported to speak to their counterparts on a regular basis as staff from Cape Vincent

100 IBID
101 IBID
102 IBID
Parameterizing Solutions

There are several requirements that must be met in order for an acceptable solution to be put in place. First, there must be continued and increased collaboration with the various stakeholders that have been identified. Conservation of a biological species does not just involve those that are knowledgeable about the biology of a species, but also regulatory and governmental bodies that are willing to implement policies and actions that can help enforce the conservation of a particular species.

A second requirement is the need for more research. Field surveys to assess population statuses and habitat improvement need to be regularly monitored and updated. The more that is known about the lake sturgeon’s life history, biological needs, and past versus present ranges, the more successful the solution development process and overall management will be. One area especially noteworthy of future research is the ecology of free ranging populations. More information on these free ranging populations will help to form accurate strategies concerning the most effective management requirements and parameters for reintroduced or rehabilitated lake sturgeon populations.

Third, a reduction in the fragmentation of aquatic habitat is necessary for the rehabilitation of lake sturgeon populations. Habitat degradation is a major threat affecting sturgeon populations and if it does not decrease, all potential solutions will face limitations. Fourth, there needs to be cooperation between lake sturgeon restoration efforts and efforts within New York that are addressing zebra mussels because zebra mussel presence significantly hinders

---

sturgeon population growth rate.\textsuperscript{104} Directly tied to all these requirements is increased funding from hydropower companies and state and federal conservation agencies. Increased funding from these various sources is contingent on the fact that the problem of lake sturgeon decline be brought to the attention of the residents of Northern New York. Therefore, there needs to be increased public awareness and support for sturgeon recovery efforts. This can be done by facilitating articles for newspapers and magazines, providing live specimens to public aquariums, and introducing educational programs into local schools.

The issue of low lake sturgeon numbers has numerous facets which will make restoration a long term process. A satisfactory solution to the problem will be achieved when 1) the status of lake sturgeon in New York is changed from Threatened to Vulnerable and 2) lake sturgeon populations have been enhanced and are strongly recovering. Strongly recovering will be defined by an increase in recruitment and increasing numbers of reproductive adult individuals that successfully spawn in selected waters. A healthy lake sturgeon population in the North Country could also result in fishing permits.

Identification of potential solutions

There are several potential solutions that can and have been used to address low lake sturgeon populations. This section will highlight five different potential solutions, each described in detail below.

\textit{Egg Takes}

One potential solution to combat the problem of declining lake sturgeon populations is egg takes. The same egg take method was implemented in both 2009 and 2010 in the St. Lawrence River, and the process as it was carried out in 2009 is described below to provide a

\textsuperscript{104} McCabe et al. 2006
background of the method. New York began a propagation program in 1993 as part of a statewide lake sturgeon recovery plan, but that program was shut down in 2006 because of the emergence of Viral Hemorrhagic Septicemia in the St. Lawrence River.\footnote{Klindt, 2009} Despite this setback, in 2009 the New York Oneida Fish Culture Station in Constantia, New York, along with SUNY Cobleskill, created quarantine facilities to culture fish eggs from non-certified broodstock. The capacity to culture eggs minimizes the chance of disease transmission, which is why it was decided that the lake sturgeon propagation project would be allowed to continue.

Prior to the collection of broodstock, holding tanks with circulating river water were setup on the NYPA property adjacent to the South Channel of the St. Lawrence River below Massena.\footnote{IBID} Sturgeon were collected in the St. Lawrence River, next to the Moses-Saunders dam in Massena. Collection took place over a period of several days and once a sturgeon was caught, it was assessed for a variety of factors including length, weight, and gender.\footnote{IBID} All fish that were caught received PIT tags which will help researchers be able to identify them in the future. Females were examined with a Hypodermic Egg Extractor (HEE) which was inserted in the coelom and if eggs were present, the suction applied from the syringe was successful at removing the eggs.\footnote{IBID} Previous egg takes (through 2004) used Common Carp Pituitary Hormone as a hormone injection, but a switch was made in 2006 to a synthetic material, Luteinizing Hormone Releasing Hormone analogue (LHRHa).\footnote{Klindt, 2009} Dosage rates of LHRHa for male and female lake sturgeon were 0.01 and 0.05 mg/kg, respectively. In 2009, sperm was harvested from nine ripe males and within one to two minutes post fertilization, eggs were treated with

\begin{footnotes}
\footnote{Klindt, 2009}{Klindt, 2009}
\footnote{IBID}{IBID}
\footnote{IBID}{IBID}
\footnote{IBID}{IBID}
\footnote{IBID}{IBID}
\footnote{Klindt, 2009}{Klindt, 2009}
\end{footnotes}
Fullers Earth for de-adhesion and a 50ppm iodophore to meet New York state decontamination protocol.\textsuperscript{110} Eggs were then mixed for one hour before rinsing and bagging before they were transported to the Oneida Fish Culture Station and SUNY Cobleskill for rearing. The sturgeon were held for 14 days post egg collection as is required by the United States Fish and Wildlife Service when using LHRHa to induce spawning.\textsuperscript{111}

In 2009, a total of 92 sturgeon were collected for evaluation as broodstock and ripe males represented 54\% of the catch whereas gravid females represented only 2\%. Selection of males for egg take is based on the production of sperm upon abdominal palpation and condition of scutes while female selection is typically based on a limited number of fish.\textsuperscript{112} Both of the two females caught in 2009 produced mature eggs via the HEE technique. Overall, approximately 114,000 eggs were taken from nine stripping events. Eggs failed to show any signs of development at either culture facility within two days of the egg take. Seven days after the take, still no development had taken place and 100\% mortality was concluded.

Historically, the egg take method had great success. In 2006, LHRHa was used with excellent results, yet the results suggest that sturgeon were potentially overdosed as the timeframe to egg maturation was accelerated by several hours. Therefore, in 2009, the female dose was decreased by 50\% and because males were essentially ripe at the time of collection, the dose given was decreased by 90\%. Two major changes implemented in 2009 that were not used in past years were egg verification with HEE and the treatment of fertilized eggs with iodophore.\textsuperscript{113} The HEE technique was determined to be less invasive than the previously used

\textsuperscript{110} IBID  
\textsuperscript{111} IBID  
\textsuperscript{112} IBID  
\textsuperscript{113} Klindt, 2009  

36
surgical technique while still providing adequate visual confirmation of mature eggs.\textsuperscript{114} Another consideration that warrants more examination is the staging of eggs. Hormone induction does not affect egg maturation, only ovulation and therefore it is possible that immature eggs are being used for fertilization.\textsuperscript{115} No conclusive conclusion has been reached as to why the eggs failed to develop. The egg take method synchronizes the spawning event with the aid of hormone injections and lake sturgeon egg takes are a potential means to bolster populations.

\textit{Fish Hatcheries}

A second potential method is the use of fish hatcheries. Traditional hatcheries are permanent structures that are designed to house and raise young fish in a controlled, artificial environment. The fish hatchery on the shores of Oneida Lake is the only hatchery in the state of New York that raises lake sturgeon. Two examples of the success of stocking waters with lake sturgeon fingerlings are described below to provide a sense of how hatcheries are used in the lake sturgeon context.

First, in Oneida Lake, large stocking efforts have been implemented such that nearly 8,000 fingerlings have been stocked since 1995.\textsuperscript{116} A monitoring program conducted by Cornell Biological Field Station reported that the sturgeon exhibited very high growth rates; growth rates from age one to age 12 years were found to be significantly faster than other populations where length-at-age data is available for these age classes. Data suggests that 36\% of fish stocked in 1995 were present at Oneida Lake in 2002 (95\% CI: 18-53\%).\textsuperscript{117}

Second, the Genesee River was identified as a possible target water for lake sturgeon restoration via “experimental stocking of hatchery reared fish into areas where the original

\textsuperscript{114} IBID
\textsuperscript{115} Carlson et al. 2010
\textsuperscript{116} Brooking and Schlueret, 2011
\textsuperscript{117} Brooking and Schlueret, 2011
populations have been extirpated for an applied evaluation of the current available habitat suitability.”\textsuperscript{118} The river received 1,900 fingerlings in 2003 through 2004 and by July of 2009, 733 individuals had been recaptured and tagged. The average catch rate was two to four lake sturgeon per net per night.\textsuperscript{119} Multiple recaptures of marked lake sturgeon allow for analysis of individual growth patterns, which is very beneficial because it can help to provide a more holistic picture of the success of a stocking effort over time.\textsuperscript{120}

\textit{Artificial Reefs}

A third potential solution to increase the number of lake sturgeon in Northern New York is the construction of artificial reefs. Clean gravel beds and large broken limestone bottoms have proven to be preferred by lake sturgeon, compared to muddy substrates or boulders, which slow down water flow and choke fertilized eggs.\textsuperscript{121,122} Artificial reefs have been successful in the midwest. For instance, in the Detroit River, scientists observed increased lake sturgeon numbers around artificial limestone reefs just one year after construction compared to other parts of the river which had different substrate materials.\textsuperscript{123} Artificial reefs were constructed in the St. Lawrence River in 1995. They were much less successful than those created in the midwest, yet reefs are another potential solution.

\textit{Dam Technology}

A fourth potential solution exists in regards to dams. Recent technological advancements and engineering research has demonstrated that the construction of passageways around dam facilities has allowed for an increase in upstream and downstream mobility. There have been

\begin{itemize}
\item \textsuperscript{118} IBID
\item \textsuperscript{119} IBID
\item \textsuperscript{120} IBID
\item \textsuperscript{121} Johnson et al. 2006
\item \textsuperscript{122} Roseman et al. 2011
\item \textsuperscript{123} IBID
\end{itemize}
numerous advancements in the development of such passageways, ranging from elevators to fish friendly hydro-turbines. These turbines have been found to decrease fish mortality, yet still maintain the high energy requirements needed for power production. Fish friendly hydro turbine design is still in the beginning phases, but it holds high prospects as a potential solution, and many hydroelectric companies have shown interest in them. Each form of technology-based passageways is dependent upon varying operational windows. Operational windows are a significant component of the passageways because they attempt to comprise information concerning the biological parameters of waterways, variations in dam structures, as well as effective guidance and attraction of fish. Furthermore, all dams in the North Country could be removed as a potential solution.

*Streamside Rearing Facilities*

Lastly, a new method of raising lake sturgeon has developed called streamside rearing facilities (SRFs). SRFs are portable trailers located near specific water bodies where lake sturgeon are known to occur. Fertilized eggs or larvae are removed from the river or stream and raised in tanks that are pumped with the water that the sturgeon were collected from. The fact that the rearing tanks are fed water from the stream that the lake sturgeon were collected form is very important as it allows the juvenile lake sturgeon to imprint on the water while still in an artificial environment. This prepares the young lake sturgeon for the exact environmental conditions they will be released in. This is included as a potential solution because it has been used in Michigan and Wisconsin with success.

---

124 Alden Fish-Friendly Hydropower Turbine Development & Deployment, 2010
125 Baker et al. 2006
Identification of feasible solutions

Five potential solutions have been identified: egg takes, fish hatcheries, artificial reefs, dam technology, and SRFs. Of these five, egg takes and artificial reefs are not feasible. The egg take method is infeasible because of the recent problem of 100% egg mortality. There is currently no consensus as to what is causing egg takes to fail, especially since the method used to work in the past. According to Ms. Holst, some possible reasons that the DEC believes that they are getting 100% mortality may be due to environmental toxins, such as estuarine in the water.\textsuperscript{126} The DEC also believes it could be a procedural problem and an outside expert from Wisconsin is being brought in at the end of May to help aid the DEC.\textsuperscript{127}

Artificial reefs are not feasible because of their lack of success in the St. Lawrence River and because of the significant amount of time, money, and materials needed to sustain them. Gravel beds need to be maintained and cleaned to prevent sedimentation and the growth of thick algae, which could deter lake sturgeon from spawning.\textsuperscript{128} Reefs are not likely not the best option for the St. Lawrence River and its larger tributaries as the reef that was built in 1995 was not successful at increasing spawning. During the 1996 and 1997 spawning cycles, very few lake sturgeons reproduced, and the eggs did not survive primarily because of predation by other fish also attracted to the clean gravel substrate.\textsuperscript{129} Also, placing large limestone rocks in portions of the St. Lawrence may pose a problem to large cargo vessels crossing shipping channels. Reefs are largely regarded as an experimental method that should be implemented only if all other

\textsuperscript{126} Holst Personal Communication, 2012
\textsuperscript{127} IBID
\textsuperscript{128} Johnson et al. 2006
\textsuperscript{129} Johnson et al. 2006
options have been exhausted.\textsuperscript{130} The constant need to maintain artificial reefs makes it difficult to imagine these new habitats being successful in the long term.

Eliminating egg takes and artificial reefs leaves fish hatcheries, dam technology, and SRFs as feasible solutions. The fish hatchery at Oneida Lake is certainly feasible, however the method does not adequately address the importance of genetic viability as a measure to ensure successful lake sturgeon rehabilitation. Fitness and survival are only maintained when extant genetic variation is not lost.\textsuperscript{131} While restocking efforts are the most popular strategy for increasing lake sturgeon numbers throughout New York and the Northeastern United States, they must be done carefully to ensure genetically similar individuals are released into the correct water bodies. Source individuals need to be evaluated thoroughly because mixing genes of different populations could result in outbreeding depression. Outbreeding depression will result in offspring that are not properly adapted to the environmental conditions in a particular water body. This knowledge aside, finding healthy, genetically similar individuals for restocking efforts has proven to be a challenge. For example, the lake sturgeon hatchlings stocked in Oneida Lake in 1995 came from very low numbers of adult fish from the St. Lawrence River population. The gametes of only two females and four males were used to create the 1995 age class for Oneida Lake.\textsuperscript{132} This is disconcerting considering the potential inbreeding that may now occur in this restocked lake. Restocking is currently a good option for bringing back lake sturgeon in their current waters, however restocking methods must be judiciously executed to maintain genetic viability in existing populations. Hatcheries are successful at stocking lake

\textsuperscript{130} Fielder and Baker, 2004
\textsuperscript{131} McQuown et al. 2003
\textsuperscript{132} Brooking et al. 2010
sturgeon and have helped populations to grow, yet they do not entirely address genetic concerns that are extremely important, and for that reason they only make up one part of the best solution.

In relation to dams and passageways, a concrete understanding of their ability to be adjusted accordingly to the specific biological attributes of a water system and the impacts a dam has on a waterway needs to be evaluated. Both of these factors also influence the actions and life cycles of lake sturgeon. Management plans that include passageway technology must be able to fit site-specific biological requirements that allow for successful spawning of lake sturgeon populations and ensure that conditions both upstream and downstream of a passageway is suitable for survival of lake sturgeon. Passageway implementation is a very recent technology which limits available information on their use and success because not enough time has passed to allow for long term monitoring. However, Alden hydropower turbine pilot testing found that survival rates ranged from 95-100% for a majority of the fish species tested.133 Such high survival rates show immense progress and hope for the future. Dam technologies have the potential to decrease lake sturgeon susceptibility to dams, yet there are numerous knowledge gaps regarding how lake sturgeon may make use of passageways. Passageways for lake sturgeon are a feasible option with much future promise but the need for more concrete understanding and research is pending and thus dam technologies cannot be moved to a best solution.

133 Alden Fish-Friendly Hydropower Turbine Development & Deployment, 2010
Figure 4. A diagram modelling the fish friendly turbine as used by Alden hydropower. \(^{134}\)

\(^{134}\) Alden Fish-Friendly Hydropower Turbine Development & Deployment, 2010
Figure 5. Knowledge gaps surrounding passageways for lake sturgeon, thus indicating areas of future research.  

Streamside rearing facilities are included as a feasible solution because of their success in Michigan and Wisconsin. For example, annual average total length of sturgeon raised in SRFs was comparable with that of fish reared in other agency hatcheries within the Lake Michigan basin during 2004 and 2005. Additionally, fish in the SRFs exhibited greater average total

---

135 Great Lakes Fishery Trust, 2011
136 Holtgren et al. 2007
length at release than fish reared in other hatcheries during 2006.\textsuperscript{137} More studies about such facilities are beginning to surface in the literature and they are certainly a feasible option for Northern New York as will be described below. Most importantly, they address the genetic considerations which are critical to boosting lake sturgeon populations. For this reason, they constitute the second part of the best solution.

Identification of best solutions

The best solution to this conservation problem is two fold; keeping the use of traditional fish hatcheries and supplementing that work with SRFs. Currently, traditional hatcheries are being used to rear and then stock lake sturgeon such as the hatchery on Oneida Lake, and this facility would remain in operation. Historically, the NYSDEC has been involved in activities where they take lake sturgeon eggs from a site in Canada, raise them at Oneida Lake, and stock them in a third, different water body and because this method has yielded successful spawning individuals over time, the DEC feels that there is only some merit to the idea of imprinting, according to Ms. Holst. However, the maintenance of genetic diversity over time is very significant and studies have demonstrated that streamside rearing facilities produce lake sturgeon with higher genetic diversity and that are more closely related to wild cohorts.\textsuperscript{138} Because both hatchery and SRF methods are focused on rehabilitating and maintaining natural populations of lake sturgeon, combining the two would provide a great way for populations to recover in Northern New York.

\textsuperscript{137} Holtgren et al. 2007
\textsuperscript{138} IBID
Ease of implementation

Streamside-rearing facilities can be easily implemented and would help aid Threatened lake sturgeon populations. There are several factors that must be taken into consideration when proposing a solution to an environmental issue and the factors of cost, cultural/heritage values, fear of change, and failure to reach consensus between stakeholders will be addressed in turn.

Cost of implementation

The cost of a single SRF trailer is $64,350 which can be broken down into $61,000 for construction, $3,000 for maintenance, and $350 for staff training. The electronic costs of operating the water pumps would be approximately $100 per month. Three SRFs are proposed for Northern New York, as illustrated below and hydropower companies such as NYPA and Brooksfield Power will pay for the SRFs. Three trailers would total $193,050. Hydropower companies are worth billions of dollars and some companies more so than others have given millions of dollars towards environmental stewardship projects. For example, NYPA gave $1.5 million dollars to have eel ladders constructed on the Mose Saunders Dam in Massena. These companies clearly have the financial backing to support a conservation effort that costs thousands of dollars.

Cultural/Heritage Values

Streamside rearing facilities will not conflict with any cultural and heritage values. In fact, it is plausible that the Akwesasne could construct an SRF on their land using funds from the Great Lakes Restoration Intiative. Doing so would allow them to continue their own lake sturgeon restoration projects on their own terms.

---

139 Holtgren et al. 2007
140 IBID
Fear of change

This implementation plan supports the continued use and functioning of lake sturgeon hatcheries, which in New York state refers to the hatchery on Oneida Lake. The success of traditional fish hatcheries is not to be undermined as they can stock several different water bodies covering a large area and they also employ many people.

Failure to reach consensus

It is anticipated that all stakeholders involved in this issue will agree with the proposed best solution. The key component to the best solution is the support of hydropower companies as they could use this opportunity to step up to stewardship goals. The NYPA has assisted in several aquatic conservation projects and therefore it is likely that they may be willing to jump in on this SRF method. Other companies such as Brooksfield Power have been involved in very few conservation projects and the implementation of SRFs in New York would be an excellent opportunity for them to bolster their stewardship credibility.141

Step-by-step implementation plan

Streamside rearing facilities are the best solution for the recovery of lake sturgeon in Northern New York. SRFs offer optimal conditions that help hatchlings imprint and thrive in their natal streams, increasing the recruitment and survival rate significantly in water bodies where they are utilized.142 Implementing three SRFs would be feasible in this area. Below are sections that address each aspect of the SRF implementation plan including proposed locations of trailers, who will monitor progress, and SRF design.

---

141 This information was gleaned off of each companies website
142 Crossman et al. 2010
One SRF would be located on the St. Lawrence River at the Awkesasne nation (the top right circle). Because of the funding that the Awkesasne nation has received through the Great Lakes Restoration Initiative, this would be an ideal location for an SRF. A trailer on tribal land would directly benefit their community and it would also help to bolster lake sturgeon populations within the St. Lawrence River. However, because individuals from the Awkesasne Environmental Division were unable to be contacted, the likelihood of this proposed location is unsure. A second SRF would be located on the St. Regis River (the middle circle). SRFs are parked in a location for approximately five months and because they are portable, the trailer
would be located on the St. Regis River during one season and then moved to the Raquette River for the next season. A third SRF will be placed on the Grasse River (the circle on the green line) and again, this trailer will be shared between the Grasse and the nearby Oswegatchie River. The sharing of trailers between major historical waterways will help decrease the overall cost.

**SRF Design**

![Figure 7. Actual depiction of an SRF trailer.](image)

The SRF design would be modeled after those SRFs that are currently being used in the Midwest. The trailer is parked near to the specific water body that lake sturgeon are being collected from and power is supplied by a propane fueled generator. The water intake system (Figure 8A) is designed for simple installation and removal and takes into consideration variable physical characteristics of the water body such as river flow and sediment load. The pump (Figure 8B) moves water with high sediment load and water enters and exits the pump through intake and discharge port. Sediment has been identified as a potential problem in the SRF method such that loading of silt in rearing tanks can cause feeding problems. Therefore, a

---

143 Holtgren et al. 2007
sediment trap (Figure 8E-G) is a critical component of SRFs and have been successful at removing about 80% of particulates. However, tanks will most likely still have to be siphoned out daily to remove the remaining particles. Nitrogen accumulation is another important factor that needs to be considered in the SRF method since the pumping of water under pressure and the introduction of air can result in high nitrogen levels. Water diffusers (Figure 8H-I) are placed at the infall point for each rearing tank that help to dissipate nitrogen build up and increase aeration.

Lake sturgeon larvae are raised in two fiberglass tanks (Figure 9C). Larval rearing tanks rest on top of juvenile raceways and are removed when the fish are transferred to larger raceway tanks. Water from each rearing tank drains into two inlet ports and the outfall location is downstream of the water intake to prevent mixing. Additionally, lake sturgeon are very sensitive to light intensity during their early developmental stages and so windows and skylights (Figure 9F-G) are an important element of any SRF trailer. Brine shrimp are fed to the lake sturgeon and the shrimp are raised in their own, separate hatchers within the trailer. As the sturgeon mature, they are gradually weaned off the diet of brine shrimp and onto a diet of chironomid larave and eventually are fed these chironomid larvae via an automatic belt feeder. Each trailer also comes equipped with countertop work surfaces and an automated phone dialing system in case of an emergency like a power failure. The streamside rearing facilities that are in use in the midwest are raising high densities of lake sturgeon because that area supports a fishery and rearing tanks can hold up to 200 to 900 fish, with an optimal density at approximately 461 fish per tank. It is likely that if SRFs were to be implemented in New York, fewer lake sturgeon would be raised

---

144 Holtgren et al. 2007
145 Holtgren et al. 2007
per trailer. Each trailer is parked at a specific water body for approximately five months as that is how long it takes to raise a larval lake sturgeon to a fall fingerling.

Figure 8. Schematic drawing of the outside of an SRF, as used in the Midwest.$^{146}$

Figure 9. Schematic drawing of the inside of an SRF, as used in the Midwest.$^{147}$

---

$^{146}$ Holtgren et al. 2007
SRF Monitoring

Scientists and associated academic institutions will be responsible for the continued surveying and monitoring of SRFs. Facilities in Wisconsin and Michigan are monitored in collaboration with large state universities and natural resource agencies of each state, respectively. Continued monitoring is extremely important because it will help to provide a holistic picture of population numbers and the maintenance of genetic diversity over time. Also, if SRFs are placed near towns, they can offer educational opportunities to the community, and demonstrate to people first-hand the restoration efforts taking place to bring back lake sturgeon.

Ms. Holst was contacted via email about the possibility for the implementation of SRFs in New York and stated that at this moment in time, there is no compelling need for SRFs within the state. Three plausible explanations as to why the DEC feels this way were then reached. The first possible reason may be funding and staffing costs. Ms. Holst did state that SRFs in the Midwest utilized students from large universities but also had to take on aquaculture professionals and with multiple trailers in multiple locations, this can add up to extra costs. A second plausible reason may be that the DEC feels that their lake sturgeon stocking program into various water bodies is successfully addressing the issue of low lake sturgeon populations. Third, it is plausible that at this moment in time, the rehabilitation of lake sturgeon is not a top priority of the DEC. These thoughts were shared with Ms. Holst via email and she has yet to respond. If SRFs do become a real and viable option for New York, both the DEC and United States Fish and Wildlife Service will be active.

147 IBID
148 Holst, 2012. Personal Communication
Conclusion

The lake sturgeon is a very long lived and slow maturing fish. Streamside rearing facilities address the important issue of maintaining genetic diversity. The best solution to this conservation biology issue is twofold: 1) keep traditional fish hatcheries that raise and lake sturgeon and 2) supplement that work with SRFs. As this paper has demonstrated, the maintenance of genetic diversity is a key component to helping bolster lake sturgeon populations and again this conservation issue will resolved when lake sturgeon populations in the North Country increase and their status designation in New York is changed from Threatened to Vulnerable.
Literature Cited


Baker, Ed, Eggold, Brad, and Aaron Paquet. 2006. Lake Sturgeon Restoration Using Streamside Rearing Facilities on Four Lake Michigan Tributaries. Michigan Department of Natural Resources Marquette, MI, and Wisconsin Department of Natural Resources Milwaukee, WI.


Brief History. About COSEWIC. www.cosewic.gc.ca


Brooking, Thomas, Jackson, James R., Krueger, Scott, Holst, Lisa, Loukmas, Jeff, Carlson, Douglas, Flack, Frank, Klindt, Roger, Lemon, Dave, Dittman, Dawn,

Brooking, T.E., and Schlueter, S. Lake sturgeon work group meeting summary 2011.

Brookfield Renewable Energy Partners L.P. 

Carlson, D.M., Colesante, R., Hayes, J.S., Schlueter, S. Lake sturgeon (Acipenser fulvescens) and its recovery programs in New York state.


David, T., Tarbeel, B., Jock, J. St. Lawrence/Akwesasne Lake Sturgeon Restoration. SRMT Lake Sturgeon Project Update/First Nations Perspective.


Dittman, D. Lake sturgeon work group meeting notes 2007.


Factsheet-GeneseeNY-LASr2.pdf (application/pdf Object). 2/22/2012 


IUCN Red list Taxonomy. www.iucnredlist.org/apps/redlist/details


Klindt, R. Lake sturgeon egg take 2009. NYSDEC Watertown, NY 13601.


Litwhiler, Stephen. Lake sturgeon egg take 2010.


Mailhot, Y., Dumont, P. Vachon, N. 2011. Management of the Lake Sturgeon Acipenser fulvescens populations in the lower St. Lawrence River (Quebec Canada) from the
1910s to the present. J. Appl. Ichthyol 27: 405-410.


Minnesota Department of Natural Resources.
http://www.dnr.state.mn.us/waters/surfacewater_section/stream_hydro/sideeffects.html


New York Power Authority
http://www.nypa.gov/


