Caviar and Conservation

Status, Management, and Trade of North American Sturgeon and Paddlefish

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Front cover photograph of a lake sturgeon (*Acipenser fulvescens*) by Richard T. Bryant, courtesy of the Tennessee Aquarium.

Back cover photograph of a paddlefish (*Polyodon spathula*) by Richard T. Bryant, courtesy of the Tennessee Aquarium.

TABLE OF CONTENTS

TEXT BOXES

LIST OF FIGURES

LIST OF TABLES

PREFACE

Living largely unknown or unnoticed by the public in many North American rivers, lakes, estuaries, and marine environments are various sturgeon and paddlefish species, members of an ancient family of fishes, Acipenseriformes, that dates back perhaps 250 million years. Aside from being a relic predating the era of the dinosaurs, these species are at the center of a conservation dilemma because sturgeon and paddlefish have long provided humankind with one of its most distinctive luxury foods—caviar—as well as meat and other products.

There are 28 sturgeon and paddlefish species in the world, all in the Northern Hemisphere. Best known of these "living fossils" are those of the Caspian Sea, which in recent decades have supplied 90% of the world caviar trade under labels such as Beluga, Sevruga, and Osetra. For years, the Caspian Sea fisheries produced what is widely claimed to be the highest quality caviar on the market.

Recently, however, all six of the sturgeon species native to the Caspian Sea and the rivers feeding it have undergone serious declines because of habitat loss, destruction of breeding grounds, pollution, and/or mismanaged or unmanaged fisheries, particularly in the component territories of the former Soviet Union. Five of the six resident species are now considered by the World Conservation Union (IUCN) to be endangered. TRAFFIC documented the conservation status and potential threats to Caspian Sea sturgeon populations in a 1996 report, "Sturgeons of the Caspian Sea and the International Trade in Caviar" (De Meulenaer and Raymakers 1996).

Concerns such as those expressed in the 1996 report over the long-term health, sustainability, or even survival of the Caspian Sea fishery have prompted conservationists and others to examine the potential consequences of its collapse on the world's other sturgeon and paddlefish species. If the Caspian fisheries can no longer produce enough caviar to meet market demand, the reasoning goes, where will the caviar industry turn next?

TRAFFIC North America has focused in particular on the consequences of the decline in the Caspian Sea fishery for the future of North America's sturgeon and paddlefish species. North America, and primarily the United States, is a significant importer of Caspian Sea caviar. It is also home to nine species of sturgeon (including one subspecies) and one of the world's two species of paddlefish, and has historically produced both caviar and meat from several of these species.

The history of North American sturgeon and paddlefish fisheries, however, is a troubled one. Heavy commercial fishing during various periods in the nineteenth and twentieth centuries contributed significantly to the decline and in some cases near-extinction of some species. As is discussed in the body of this report, several life history characteristics (e.g., late age at maturation, slow rate of reproduction, specific habitat requirements) render sturgeon and paddlefish particularly vulnerable to commercial overexploitation. Several North American acipenseriform species have not recovered from past declines to a point where they can withstand commercial, or even recreational, fishing pressure. One alternative to wild catch—commercial aquaculture—remains in its infancy, and thus at least in the short term any significant increase in North American caviar production from native Acipenseriformes would have to come from wild populations. This situation prompted TRAFFIC to ask a basic question: If the Caspian Sea fisheries continue to decline and industry attention shifts to North America as an alternative, what might the future hold for U.S. and Canadian populations of sturgeon and paddlefish?

This report addresses several aspects of that question, focusing on the preparedness of U.S. and Canadian management bodies, current trends in legal and illegal trade, implementation of recent listings and resolutions adopted by the parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora

(CITES), and the state of (and prospects for) commercial aquaculture and sustainable production from the wild. TRAFFIC's intent in part is to provide information to continue the dialogue among state and federal biologists, fisheries managers, policy makers, the caviar industry, fishermen, and commercial aquaculture interests that began at the Symposium on Harvest, Trade and Conservation of North American Paddlefish and Sturgeon, which was held in May 1998 in Chattanooga, Tennessee. Specifically, TRAFFIC herein examines the following:

1. The current status of North American paddlefish and sturgeon species, their historic range and current distribution, ecology and habitat requirements, historic and current catch levels, and challenges and/or threats to their conservation;
2. Federal, state, and regional management and regulatory regimes, which are reviewed to explain how sturgeon and paddlefish species are being managed at present and to assess whether systems in place are adequate to cope effectively with increased commercial pressure;
3. Current levels of and trends in legal domestic and international trade involving native North American Acipenseriformes, the possible impact of these activities on the species involved, and the application in the United States and Canada of recent CITES decisions regarding sturgeon and paddlefish trade;
4. What is known about illegal catch and trade activities, and to what extent this phenomenon might further threaten U.S. and Canadian sturgeon and paddlefish populations or undermine conservation efforts; and
5. Developments in private commercial aquaculture and other captive propagation programs, and how such ventures might provide a conservation benefit to wild populations or, conversely, present new problems or challenges to fisheries and trade management authorities.

TRAFFIC does not attempt herein to address questions of sturgeon biology or morphology, the legitimacy of designations of species and subspecies, or other such issues that continue to be widely debated in the scientific community. The fundamental focus of TRAFFIC's mission is to monitor trade in wildlife, and address issues of illegal or unsustainable harvest and trade that might threaten the conservation of wild species of fauna and flora. The subjects highlighted in this report are those that fall within those general parameters. The primary sources used to compile the information presented are fisheries management plans, catch and trade statistics, laws and regulations, and documents concerning ongoing or proposed conservation programs. We hope that the findings and recommendations included at the end of this report will advance current sturgeon and paddlefish conservation efforts.

ACKNOWLEDGEMENTS

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In particular, TRAFFIC would like to thank all of the state, provincial, and federal fisheries biologists, law enforcement officials, and other management authorities who took the time to provide the data and insights that are the heart of the report. Other information was provided by representatives of nongovernmental organizations, members of the academic community, representatives from the caviar and fishing industries, and those involved in the captive propagation and commercial aquaculture of North American sturgeon and paddlefish. This report would not have been possible without the tremendous assistance of all of these sources.

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I. Introduction

Background: The Acipenseriformes of North America

Members of Acipenseriformes in North America include the North American paddlefish (*Polyodon spathula*); the Atlantic sturgeon and its subspecies, the Gulf sturgeon (*Acipenser oxyrinchus oxyrinchus* and *Acipenser oxyrinchus desotoi*);[1] the shortnose sturgeon (*Acipenser brevirostrum*); the lake sturgeon (*Acipenser fulvescens*); the pallid sturgeon (*Scaphirhynchus albus*); the shovelnose sturgeon (*Scaphirhynchus platorhynchus*); the Alabama sturgeon (*Scaphirhynchus suttkusi*); the white sturgeon (*Acipenser transmontanus*); and the green sturgeon (*Acipenser medirostris*). There is also a recognized sub-population of the white sturgeon in the Kootenai/Kootenay River system, which the United States lists federally as an endangered species and British Columbia classifies provincially as critically imperiled (U.S. Fish and Wildlife Service [USFWS] 1994b, 2000d; B.C. Fisheries 2001a).[2] The Gulf sturgeon, pallid sturgeon, shovelnose sturgeon, and Alabama sturgeon are endemic to the United States. The Atlantic sturgeon, shortnose sturgeon, lake sturgeon, white sturgeon, and green sturgeon inhabit U.S. and Canadian waters. The range of the paddlefish historically included rivers and lakes in both the United States and Canada, but today the species is found only in the United States (National Paddlefish and Sturgeon Steering Committee [NPSSC] 1993; Graham 1997).

Paddlefish and sturgeon were once broadly distributed throughout North America. TRAFFIC's review of literature found one or more species likely to have been present historically in at least 45 U.S. states and 10 Canadian provinces and territories. There was no historical record or mention of acipenseriform presence only in Arizona, Colorado, Hawaii, Nevada, and Utah in the United States, and Nunavut, the Northwest Territories, and the Yukon Territory in Canada (Gengerke 1986; NPSSC 1993; Hesse and Carreiro 1997; Hochleithner and Gessner 1999).

Today, native sturgeon and paddlefish populations continue to inhabit the vast majority of U.S. states and Canadian provinces, but the range and abundance of many species is significantly reduced. In some cases the historic or contemporary presence of a particular acipenseriform species is difficult to confirm. For instance, sightings of pallid sturgeon in some U.S. states are so rare or have not been documented for so long that the species' continued existence in those jurisdictions is uncertain (USFWS 1990). Similarly, it is uncertain whether remnant natural populations of lake sturgeon still exist in some river systems where habitat alterations and other factors are believed to have largely, if not completely, extirpated the species. Acipenseriform species may also turn up occasionally in North American waters where they are not normally found because of flooding or other unusual conditions. Such is the case in Florida's Apalachicola River, where paddlefish are sometimes reported during periods of very high water, even though Florida lies outside of the species' usual range (James Estes, Chief, Bureau of Freshwater Fisheries Resources, Florida Fish and Wildlife Conservation Commission, *in litt.* to Teiko Saito, Office of Management Authority, USFWS [USFWS/OMA], August 18, 2000).

Reasons for Concern About North America's Acipenseriformes

North American sturgeon and paddlefish are the subject of significant conservation interest and concern, both domestically and internationally. Primary reasons for concern about these species include issues of biology and ecology, management, commercial trade, and potential threats posed by disease, hybridization, or introduction of non-native species.

Certain biological and ecological characteristics present a challenge to the

[1] Many reference sources also use the spelling "oxyrhynchus" for this species.

[2] The spelling differs in the United States and Canada. In the United States it is the Kootenai River; in Canada it is the Kootenay River.

conservation of Acipenseriformes. Their long lives (individuals of some species have been aged at more than 100 years), relatively slow growth, and generally late age of sexual maturity (10–20 years for some species) make them slow to reproduce (NPSSC 1993; Haywood 1999; Musick 1999). In addition, sturgeon and paddlefish species have specific ecological requirements and are particularly vulnerable to spawning and nursery habitat destruction because of their migratory and, in some species, anadromous behavior (NPSSC 1993; Musick 1999). Largely for this reason, common themes appear repeatedly in explanations of why many North American sturgeon and paddlefish populations have decreased over the past century or more. Human-caused habitat modification and degradation (e.g., dams, channelization, dredging, pollution) and their resulting ecological impacts (blocked migration corridors, loss of spawning and feeding grounds, deterioration of water quality, etc.) are frequently cited as root factors in the decline of North American acipenseriform species. Such ecological concerns are not just historical phenomena. Man-made alterations of critical natural riverine, estuarine, and marine ecosystems are ongoing and, as is discussed in greater detail in Section III of this report, pose a continuing threat to many North American acipenseriform species and populations.

Management practices, particularly as they relate to commercial and sport fishing, are another category of concern. It is believed that overfishing, particularly during periods of "boom-and-bust" commercial fishing for the caviar industry, played a significant role in the historical decline of many of these long-lived, slow-reproducing species. For example, Atlantic sturgeon stocks in the United States' Delaware Bay were nearly extirpated by overfishing during little more than a decade in the late nineteenth century, and have shown little recovery since (Musick 1999; Secor and Waldman 1999). Several North American acipenseriform species or populations are now listed as endangered, threatened, or in need of special protection measures in the United States and Canada. Other North American Acipenseriformes continue to be fished. As is detailed in Section IV of this report, there are fisheries in the United States involving the paddlefish (commercial and sport), shovelnose sturgeon (commercial and sport), lake sturgeon (sport), white sturgeon (commercial and sport), and, to a limited degree, green sturgeon (commercial and sport). Canada has fisheries involving the Atlantic sturgeon (primarily commercial), and lake sturgeon (commercial and sport). For these species, balancing the interests of commercial and recreational fishers against conservation needs is a delicate issue for fisheries agencies. Ensuring that the levels of catch remain sustainable is a primary consideration for fishery managers, conservationists, and, if the resource is to remain available in the long-term, the commercial and sport fishing industries as well.

A likely increase in demand for North American caviar as an alternative to Caspian Sea product in domestic and international markets presents a third issue for concern. In recent decades, Caspian Sea fisheries have produced an overwhelming preponderance of the caviar in international trade. Since the dissolution of the Soviet Union, however, mismanagement, lack of funding, deterioration of infrastructure (hatcheries, etc.), illegal catch and trade, and lack of adequate law enforcement have combined to seriously threaten the resource base. A recent 2002 decision by USFWS to propose listing the highly prized Beluga sturgeon (*Huso huso*) as endangered under the Endangered Species Act (ESA) is indicative of the high level of concern being expressed by many people about the situation facing Caspian Sea sturgeon species (USFWS 2002a). As is described in Section V of this report, TRAFFIC has serious doubts that the comparatively limited fisheries for sturgeon and paddlefish in North America could produce enough caviar to substitute for Caspian Sea sources, should that fishery truly collapse. The section notes that demand for caviar in major caviar-consuming countries, primarily the nations of the European Union (EU), Japan, and the United States, is far above what North American fisheries and commercial aquaculture operations are currently producing. Ensuring that rising demand for North American caviar in domestic and international trade does not lead to a repeat of past periods of overfishing may prove to be a serious challenge.

Finally, relatively recent developments such as the introduction of competitive foreign species and non-native pathogens, and the advent of captive propagation and commercial aquaculture programs for North American Acipenseriformes, have raised new sets of concerns regarding the potential loss of endemic populations or strains through disease, hybridization, or genetic dilution. Iridology and bacterial studies for sturgeon diseases are in their infancy, but there is reason for some anxiety about the potential threat that introduction of non-native diseases poses to all native acipenseriform species. As is discussed in Section VI of this report, the outbreak in 2000 of an iridovirus at hatcheries rearing pallid sturgeon for release as part of a recovery program emphasized the need for vigilance and caution in such efforts. Such concern increases when the very real possibility of accidental releases from public hatcheries or private aquaculture facilities is factored in, particularly regarding those that may be rearing non-native species.

Of course, none of these concerns, as loosely categorized above, should be examined in a vacuum. Their potential impacts on North American Acipenseriformes interrelate, and should be explored in combination to ascertain the overall effect on each of North America's native species. Because a comprehensive analysis of every one of the challenges facing North American sturgeon and paddlefish falls outside of the scope of this report, readers are encouraged to refer to the literature cited in Section III for more detail than is provided in the summaries herein.

The Purpose of This Report

In May 1998, TRAFFIC North America, in partnership with the Southeast Aquatic Research Institute (SARI) and in cooperation with USFWS, convened a Symposium on the Harvest, Trade and Conservation of North American Paddlefish and Sturgeon. The symposium's goal was to increase communication and information exchange on issues affecting North American acipenseriform species and populations, to help ensure their long-term sustainability. TRAFFIC invited federal and state fisheries managers, wildlife trade experts, caviar industry representatives and importers/exporters, fishermen, federal regulatory and legal authorities, members of the scientific and academic communities, and interested nongovernmental organization representatives to discuss a range of issues. These included the status of populations, management challenges and concerns, domestic and international trade, captive propagation and aquaculture, and ways to increase the flow of information and dialogue among the various constituencies and interests represented.

This report follows up on some of those same issues, as reviewed by TRAFFIC North America four years later. It attempts to summarize, explain, and provide critical analysis of how past and current ecological alterations, management practices, trade trends, and other factors have affected North America's acipenseriform species to date. In doing so, TRAFFIC's intent is twofold. First, we hope that the information and analysis in this report will help to clarify some of the issues involved in the debate over the future conservation and management of North American sturgeon and paddlefish, as well as identifying specific areas where further research and investigation are necessary. Second, TRAFFIC hopes that the recommendations provided herein will help to promote progress toward requisite legal, regulatory, and other actions necessary to ensure the long-term survival of this ancient, unique, and valuable group of species.

The Structure of This Report

Determining an appropriate structure to present the information gathered for this report proved somewhat difficult. TRAFFIC identified three primary audiences, with different informational needs.

Because TRAFFIC's fundamental mission is to monitor wildlife trade, an essential intended audience for this report comprises fisheries authorities, conservationists, and others interested in how issues and management approaches regarding conservation status, threats or challenges, commercial and sport fishing, and captive propagation or commercial aquaculture cross-compare or differ among North America's acipenseriform species, especially as they relate to trade in caviar and other products. To accommodate the needs of

this primary audience, the major sections in the report are structured thematically.

TRAFFIC is aware, however, that many readers are likely to have a particular interest in one or more specific North American acipenseriform species, and so might prefer to have the information presented in a species-by-species format. For this readership, TRAFFIC attempted wherever practical to subdivide the major sections of the report by species. Some of the information in the individual sections may therefore appear to be somewhat redundant. For example, many of the threats or challenges facing the conservation of North American acipenseriform species, detailed in Section III, are similar (e.g., habitat loss or degradation, pollution, overfishing). Such information is nevertheless reiterated in the body of this report as it applies to each species, for the convenience of those readers who may want to skip through the thematic sections and focus only on those specific North American Acipenseriformes that interest them.

Lastly, TRAFFIC knows that some readers may want only a general synopsis of North American acipenseriform species and key issues involved in their conservation. For these readers, it was important to synthesize key data into a convenient format, through which they can see the broad outlines of the report and decide which particular species or issues they may wish to examine further. For this group of readers, the general overview provided in Section II of this report may prove sufficient.

Following this introduction, the report proceeds along the following lines.

Section II: General Overview. This section provides a thumbnail sketch of the information presented in later sections of the report on the status of North American sturgeon and paddlefish species, threats and challenges, legal classification, commercial and recreational fisheries, trade, and captive propagation and commercial aquaculture. Section II attempts to condense available data into an accessible format that allows for easy cross-comparison among species and political jurisdictions. It is intended for those readers who are not interested in the full details of the report, and also as a convenient reference section for all readers.

Section III: Species Summaries. TRAFFIC reviewed available literature, management plans, and other documentation regarding the status of each of North America's paddlefish and sturgeon species. The review included examining what is known about these species historically, as well as what is known about each today. TRAFFIC found very different amounts of information for each species. The life history characteristics of some of these fishes and their relationship to and utilization by people are well documented. In other cases, some North American sturgeons were not recognized as separate species until fairly recently, and little is known about their life history characteristics, ecological and habitat needs, or historical fisheries and catch levels. TRAFFIC herein attempts to summarize known information on each species, and to highlight gaps in knowledge and other issues facing fisheries authorities and conservationists.

Section IV: Management and Regulation in the United States and Canada. This section attempts to elucidate how each native acipenseriform species is managed in the United States, Canada, or, where applicable, in both countries. Central issues include the various species' legal classifications, what authorities have management jurisdiction, and whether current management regimes are adequate to meet increasing demand for the caviar trade. The section draws heavily on existing recovery plans for those acipenseriform species that have been federally listed as endangered, threatened, or of special concern. Regarding those species for which federal, state, and provincial authorities allow commercial or recreational fishing, the section highlights relevant laws and regulations governing catch and possession, as well as conservation measures in place or proposed to maintain the abundance of stocks.

Section V: Legal and Illegal Trade. In June 1997, international concern over the decline of Caspian Sea fisheries and the potential consequences for other sturgeon and paddlefish species led the Parties to the Convention on International Trade in Endangered Species of Fauna and Flora (CITES) to place all previously unlisted acipenseriform species in CITES Appendix II. The listing entered into effect in

April 1998, and parties to the Convention are now obligated to regulate and monitor international trade. This section examines the current (2002) status of legal trade in North American paddlefish and sturgeon species, as well as implementation of the CITES listing in the United States and Canada. TRAFFIC also examines what is known about illegal catch and trade in North America, and the prospects that such activity could grow into a serious threat to native species.

Section VI: Hatcheries and Commercial Aquaculture. In the United States, federal and state fish hatcheries have been captive-propagating paddlefish and native sturgeon species for many years to facilitate restoration, reintroduction, stocking, and research programs. Traditionally, captive propagation of sturgeon has been less widespread in Canada, although there is some activity. There has also been growing interest in recent years in the commercial aquaculture, or "fish-farming," of several acipenseriform species, particularly in the United States. This section summarizes captive propagation and commercial aquaculture programs and initiatives in the United States and Canada. It then examines various issues and questions regarding both practices and what role they might play in the future conservation of North American paddlefish and sturgeon species.

Section VII: Conclusions and Recommendations. At the end of the report, TRAFFIC presents a set of conclusions and specific recommendations on each of the aforementioned topics. We hope that the ideas and actions suggested will be considered by fisheries managers, law enforcement authorities, representatives of the CITES Secretariat and Parties, and other individuals and organizations in the public, nongovernmental, and private sectors interested in paddlefish and sturgeon conservation.

II. General Overview

The following summaries and tables track the thematic outline of this report. Because the major sections of the report are subdivided by species where possible, the tables below attempt to pull together information for comparison in a species-by-species and jurisdiction-by-jurisdiction format. Not all of the subject matter discussed later in the report proved easy to condense, however. For example, information on illegal trade in caviar and other products is often anecdotal, and therefore proved difficult to distill into table format.

The sheer number of sources (literature, *in litt*. correspondence, personal communication, etc.) used to compile the information in this report also made it impractical to try to cite the individual source(s) of every piece of data in each of the summary tables below. More detail on each of the subjects addressed in the tables, as well as the specific sources of each piece of information, are provided in sections III through VI. Readers are encouraged to use these summaries and tables as a broad snapshot of the contents of the report, and refer to the later sections for more specific information and further informational resources on topics that may interest them.

2.1 Species Summaries

Section III of this report provides basic information on each of North America's acipenseriform species, including historic range and current distribution, ecology and habitat, historic fisheries and catch levels, and conservation status and challenges/threats.

Historic Range and Current Distribution

Five North American sturgeon species—the Atlantic sturgeon, shortnose sturgeon, lake sturgeon, white sturgeon, and green sturgeon—occur in both the United States and Canada. The white sturgeon and green sturgeon also migrate into Mexican waters along the Pacific coast. The Gulf sturgeon, shovelnose sturgeon, Alabama sturgeon, and pallid sturgeon are endemic to the United States. Although the paddlefish is believed to have once inhabited waters in southern Ontario, the species is considered extirpated in Canada, and presently occurs only in the United States.

Sturgeon and paddlefish populations cross numerous political and management jurisdictions within the United States, as do some sturgeon populations within Canada. Table 2.1.1 shows the historic and current ranges of each of the North American Acipenseriformes, according to political jurisdiction. The indication of "present" in the table indicates a determination that the species continues to inhabit the jurisdiction; "extirpated" indicates some certainty among management authorities that there are no extant natural populations of species once known or reported to be present. The use of a question mark ("?") indicates uncertainty or conflicting information on whether the species in question inhabited the jurisdiction historically, or that its presence in (or extirpation from) historic range waters is unclear. More detail on such cases involving individual species is provided in Section III of this report.

Table 2.1.1. Historic and Current Range of North American Sturgeon and Paddlefish Species (45 U.S. States and 10 Canadian Provinces)*

Province/State	AtlS	GlfS	ShnS	Pd	ShvS	AlS	PS	LS	WS	GrS
Alberta								✔		
British Columbia									✔	✔
Manitoba								✔		
New Brunswick	✔		✔							
Newfoundland	✔									
Nova Scotia	✔									
Ontario				E				✔		
PEI	✔									
Quebec	✔							✔		
Saskatchewan								✔		
Alabama		✔		✔	E(?)	✔		E		
Alaska									✔	✔
Arkansas				✔	✔		✔	E		
California									✔	✔
Connecticut	✔		✔							
Delaware	✔		✔							
Florida	✔	✔	✔							
Georgia	✔		✔	?	?			E(?)		
Idaho									✔	
Illinois				✔	✔		✔	✔		
Indiana				✔	✔			✔		
Iowa				✔	✔		✔	✔		
Kansas				✔	✔		✔	✔		
Kentucky				✔	✔		✔	E(?)		
Louisiana		✔		✔	✔		✔	E(?)		
Maine	✔		✔							
Maryland	✔		✔	E						
Massachusetts	✔		✔							
Michigan				?				✔		
Minnesota				✔	✔			✔		
Mississippi		✔		✔	✔	E	✔	E		
Missouri				✔	✔		✔	✔		
Montana				✔	✔		✔		✔	
Nebraska				✔	✔		✔	✔		
New Hampshire	✔		✔							
New Jersey	✔		✔							
New Mexico					E					
New York	✔		✔	E				✔		
North Carolina	✔		✔	E	E			?		
North Dakota				✔	✔		✔	?		
Ohio				✔	✔			✔		
Oklahoma				✔	✔					
Oregon									✔	✔
Pennsylvania	✔		✔	E	E			✔		
Rhode Island	✔		✔							
South Carolina	✔		✔							
South Dakota				✔	✔		✔	?		
Tennessee				✔	✔		✔	E(?)		
Texas				✔	✔					
Vermont								✔		
Virginia	✔		✔	E(?)						
Washington									✔	✔
West Virginia				✔	E(?)			E		
Wisconsin				✔	✔			✔		
Wyoming					✔					

Key: ✔ = present; E = Extirpated; ? = Uncertain/conflicting data; AtlS = Atlantic sturgeon; GlfS = Gulf sturgeon; ShnS = shortnose sturgeon; Pd = paddlefish; ShvS = shovelnose sturgeon; AlS = Alabama sturgeon; PS = pallid sturgeon; LS = lake sturgeon; WS = white sturgeon; GrS = green sturgeon.

* Sources: Compiled by TRAFFIC North America from various species literature and studies, in litt. correspondence, and personal communications. More detailed information and specific references are provided in Section III.

Ecology and Habitat

Section III also provides basic information on what is known about the physical and life history characteristics, spawning characteristics, and habitat preferences of North America's Acipenseriformes. Because of a lack of definitive research, paucity of historical records, rarity, and the fact that some Acipenseriformes were not recognized as separate species until relatively recently, much remains unknown for some species (e.g., the Alabama sturgeon, pallid sturgeon, green sturgeon). The following tables summarize what is generally known or believed.

Physical/Life history characteristics. North American Acipenseriformes vary widely in size and weight, from the 2–4 pound (1–2 kg) Alabama sturgeon to the white sturgeon, which can reach lengths of up to 20 feet (>6 meters) and weights of close to 2,000 pounds (907 kg), and is the largest freshwater fish in North America. As a general principle, Acipenseriformes are slow-growing, long-lived fish, with cases of individual lake sturgeon and white sturgeon being aged at more than 100 years. However, as is noted below, most contemporary captures of North American sturgeon and paddlefish involve specimens that are smaller and younger than the maximum sizes and ages that have been recorded historically.

Age at sexual maturity differs among the individual species, from as few as five years for some sturgeon species or populations to close to 30 years for others. It is also noteworthy that species such as the Atlantic sturgeon, shortnose sturgeon, white sturgeon, and paddlefish exhibit clinal variations, with northern stocks or distinct population segments reaching sexual maturity much later than southern stocks, and also reaching greater ages. More specifics on species' stock structures and variations are provided in Section III. Table 2.1.2 summarizes available data on the basic physical parameters, age at maturity, and longevity of North American sturgeon and paddlefish species.

Table 2.1.2 Physical/Life History Characteristics of North American Acipenseriformes*

Species	Maximum Weight (kg/lb)	Maximum Length	Age at Maturity	Longevity
Atlantic sturgeon	368 kg (~810 lb)	4.2 meters (14 feet)	7–28+	60 yrs
Gulf sturgeon	200–225 kg (440-500 lb)	2.4–2.7 meters (8–9 feet)	7–12+	42 yrs
Shortnose sturgeon	23–24 kg (~50–53 lb)	1.4 meters (4 feet)	5–18+	30–67 yrs+
Paddlefish	80 kg (175 lb)	2.3 meters (7 feet)	5–9 (m); 8–12 (f)	30 yrs+
Shovelnose sturgeon	2.5–4.5 kg (5–10 lb)	1+ meters (3–4 feet)	5–7	27
Pallid sturgeon	30–45 kg (66–100 lb)+	1.8 meters (6 feet)	5–20+	60+
Alabama sturgeon	1–2 kg (2-4 lb)	31 inches (80 cm)	5–7	15
Lake sturgeon	140 kg (300 lb)+	2.4 meters (7 feet)+	12–22 (m); 14–27 (f)	152+
White sturgeon	907 kg (~2,000 lb)+	>6 meters (20 feet)+	10–20 (m); 15–30 (f)	>82+
Green sturgeon	160 kg (~325 lb)+	~2 meters (7 feet)+	8–10 (m); 10–12 (f)+	>40+

Key: m = male; f = female.

* Sources: Compiled by TRAFFIC North America from various species literature and studies, in litt. correspondence, and personal communications. More detailed information and specific references are provided in Section III, and below in Additional Comments.

+ Additional Comments: **Atlantic sturgeon:** Sexual maturity for Atlantic sturgeon varies widely depending on distribution, with northern populations maturing much later than southern populations. In the far northern extent of the species range (St. Lawrence River) females reach sexual maturity at 24–28 years and males at 20–24 years, while in the south females may reach maturity at 9–15 years and males at 7–9 years (Hochleithner and Gessner 1999). **Gulf sturgeon:** Huff (1975) found that sexually mature females in the Suwanee River (FL) ranged from 8 to 17 years old. **Shortnose sturgeon:** Males are estimated to reach sexual maturity at 5–12 years of age; females at 6–18 years of age. It is believed that northern populations mature more slowly than do southern populations. Oldest known female was recorded at 67 years; males believed to seldom exceed 30 years. **Paddlefish:** Paddlefish in southern stocks are believed to mature faster than those in northern stocks, but exhibit far shorter lifespans. **Pallid sturgeon:** Maximum weight—Estimates of maximum weights cited for the species vary (see Section III for details). Age at maturity—Chapman (1999) reported that pallid sturgeon reach sexual maturity at 5–20 years of age. USFWS (2000b) cited Keenlyne and Jenkins (1993) in estimating sexual maturity for males at 7–9 years of age, and female sexual maturity at 15–20 years; Longevity—Little is known about age or growth of pallid sturgeon. Chapman (1999) estimated the maximum age of the species at 39–41 years. However, a female pallid sturgeon aged following mortality in 1998 was estimated at more than 50 years of age, and possibly as high as 60 (USFWS 2000b). **Lake sturgeon:** More typically, lake sturgeon are believed to reach ~1.5 meters in length (4–5 feet), ~30 kg in weight (60–70 lb), and 40 years of age. **White sturgeon:** Maximum weight/length—Most fish caught in recent times have been much smaller; Longevity—One female caught in Oregon was aged at 104 years, but most fish caught are much younger. **Green sturgeon:** The green sturgeon's life history has not been extensively studied and documented.

Spawning characteristics. Table 2.1.3 shows some of the basic spawning characteristics of North American acipenseriform species. Details on specific migration and spawning cues (e.g., water temperature, current velocity, light intensity) are discussed (where known) in the relevant species summaries in Section III.

Habitat preferences. Five North American sturgeon species are either anadromous[1] (Atlantic sturgeon, Gulf sturgeon, green sturgeon) or have both anadromous and freshwater populations (shortnose sturgeon, white sturgeon). Shortnose sturgeon also exhibit a freshwater amphidromous form.[2] Paddlefish, lake sturgeon, shovelnose sturgeon, Alabama sturgeon, and pallid sturgeon are freshwater species, although, as is discussed in Section III, individuals of some of these species have been found occasionally in brackish waters. The ranges of several North American species overlap; however, as Table 2.1.4 shows, different habitat preferences and seasonal movements serve to largely avert competition for food or other resources.

Historic Fisheries/Catch Levels

In the United States, commercial fisheries directed at the Atlantic sturgeon, Gulf sturgeon, lake sturgeon, paddlefish, white sturgeon, and likely the Alabama sturgeon developed and peaked during the late nineteenth century. Shortnose sturgeon, shovelnose sturgeon, and pallid sturgeon may also have been caught, although for reasons explained in the table below and in more detail in Section III, these species are not thought to have been specifically targeted during this period. In Canada, late nineteenth century commercial sturgeon fisheries focused on the lake sturgeon and white sturgeon. As in the United States, Canadian stocks of these species quickly declined. A smaller Canadian Atlantic sturgeon fishery continued through the twentieth century, and still exists today. Table

Table 2.1.3 Spawning Characteristics of North American Acipenseriformes*

Species	Spawning Interval (yrs)	Spawning Season	Substrate	Fecundity (eggs/kg, 1,000s)	Oocytes (diameter, mm)
Atlantic sturgeon	1–4 (m); 3–5 (f)	April–July	Gravel or Rock	16–24	2.1–3.0+
Gulf sturgeon	1–3 (m & f)	February–April	Gravel, Small Cobble+	9–21	2.3–2.8
Shortnose sturgeon	2–3 (m)+; 3–8 (f)	March–June	Gravel or Rock	9–16+	3.0–3.2
Paddlefish	1–2 (m); 2–4 (f)	March–June	Gravel or Rock	15–20	3.3–3.9
Shovelnose sturgeon	1–>?+	April–July	Gravel or Rock	6–17	2.8–3.5
Pallid sturgeon	2–3 (m); 3-10 (f)	March–July	Not well known+	10	2.5–3.1
Alabama sturgeon	1–3	Not well known	Gravel or Rock	?	?
Lake sturgeon	2–3 (m); 4–6 (f)	April–June	Rock or Pebble	10–13	2.7–3.5+
White sturgeon	1–2 (m); 2–6 (f)	March–June+	Rock or Pebble	5–23+	2.6–4.0
Green sturgeon	2–6+	March–July+	Large Cobble+	0.6–1.0	~3.8+

Key: m=male; f=female.

* Sources: Compiled by TRAFFIC North America from various species literature and studies, *in litt.* correspondence, and personal communications. More detailed information and specific references are provided in Section III, and below in Additional Comments.

+ Additional Comments: **Atlantic Sturgeon:** Oocytes—From Chapman (1999); Hochleithner and Gessner (1999) estimated 2.3–2.8 mm. **Gulf Sturgeon:** Substrate—A substrate of exposed bedrock overlain with gravel and small cobble used by spawning Gulf sturgeon has been called a "sturgeon spawning reef" (Sulak and Clugston 1999). **Shortnose sturgeon:** Spawning interval—Some males may spawn every year; Fecundity—Hochleithner and Gessner (1999) reported female fecundity at 11,000–12,000 per kg. **Shovelnose sturgeon:** Spawning interval is not well known. **Pallid sturgeon:** Substrate—Because existing data indicate that extremely limited natural reproduction is occurring in wild populations, little information is available to delineate precise spawning areas. **Lake sturgeon:** Oocytes—Hochleithner and Gessner (1999) estimated 2.5–3 mm. **White sturgeon:** Spawning season—Spawning in the Columbia River has been reported as occurring between April and July; Fecundity—Hochleithner and Gessner (1999) estimated an average of ~5,600/kg. **Green sturgeon:** Spawning interval—Not definitely established; Spawning season—Peak believed to occur between mid-April and mid-June in California; Substrate—Large cobble preferred, but substrate reported to range from clean sand to bedrock; Oocytes—Chapman (1999) estimated a range of 3.3–3.7 mm.

[1] Anadromous species are those that migrate from marine or coastal saltwater habitats to freshwater rivers to spawn.

[2] Adults of freshwater amphidromous species live and spawn in fresh water, but regularly enter saltwater environments.

Table 2.1.4 Habitat of North American Acipenseriformes*

Species	Anadromous/ Freshwater	Habitats	Comments
Atlantic sturgeon	Anadromous	Marine; Estuarine; Riverine	Uses rivers, estuaries, bays, and the ocean at various times in their lifespans. Adults spend much of their lives in marine and near-shore waters. Highly migratory—feeding migrations up to 1,800 miles have been reported.
Gulf sturgeon	Anadromous	Riverine; Marine; Estuarine	Adults and sub-adults believed to spend 8–9 months of each year in rivers and 3–4 months in estuaries or the Gulf of Mexico, usually during winter. Juveniles likely remain in riverine habitats and estuaries year-round.
Shortnose sturgeon	Anadromous; Freshwater Amphidromous; Freshwater	Estuarine; Riverine; Marine	Confined primarily to natal rivers and estuaries, with adults migrating seasonally into marine waters. Spends most of its life in slow-moving riverine or near-shore marine waters. Some northern populations have freshwater forms.
Paddlefish	Freshwater	Riverine; Lacustrine; Reservoirs	Inhabits the moderate flow of large rivers that provide high zooplankton production. Prior to alteration of large rivers, paddlefish preferred the naturally braided channels, extensive backwater areas, and oxbow lakes of these rivers. In altered rivers, paddlefish concentrate in sheltered areas where flow velocity is reduced. Has adapted to reservoirs.
Shovelnose sturgeon	Freshwater	Riverine	Prefers the rapid currents of main river channels, and high turbidities. In altered rivers, commonly frequents the tailwaters below wing dams and other structures that accelerate current flow.
Pallid sturgeon	Freshwater	Riverine	Prefers large, turbid, free-flowing river habitats with rocky substrates, swifter than those preferred by the shovelnose sturgeon. Believed to be more specific and restrictive in the use of microhabitats than shovelnose sturgeon.
Alabama sturgeon	Freshwater	Riverine	Inhabits large channels of big rivers, although at least two historic records involved Alabama sturgeon found in oxbow lakes. Believed to prefer low-velocity currents and sandy or gravel substrates.
Lake sturgeon	Freshwater	Riverine; Lacustrine	Inhabits shallow riverine and lacustrine waters with a rocky or muddy substrate; commonly found in the highly productive shoals of large lakes and rivers.
White sturgeon	Anadromous; Freshwater	Marine; Estuarine; Riverine	Found in major rivers, estuaries, and near-shore marine environments. Some populations that once had access to the ocean now fragmented and confined to freshwater by dams.
Green sturgeon `	Anadromous	Marine; Estuarine; Riverine	Relies on streams, rivers, estuaries, and marine waters throughout its life cycle. Adults are believed to be more marine than white sturgeon, and spend comparably less time in estuaries or freshwater.

* Sources: Compiled by TRAFFIC North America from various species literature and studies, ***in litt***. correspondence, and personal communications. More detailed information and specific references are provided in Section III.

2.1.5 summarizes historic fisheries and peak catch levels for North American Acipenseriformes. Table 2.2.1 further below shows those U.S. states and Canadian provinces that currently have sturgeon and paddlefish fisheries.

Conservation Status and Challenges/Threats

Finally, Section III of this report details the conservation status of North American acipenseriform species, as measured at the national and international levels.[3] Section III also discusses major challenges or threats to their future conservation and, in the case of some species, even their continued survival.

Conservation status (national and international). In the United States, the primary federal legal mechanism to protect species deemed at risk is the Endangered Species Act of 1973 (ESA). Primary agencies charged with implementing the ESA are

[3] How North American sturgeon and paddlefish species and populations are legally classified at the state and provincial levels is addressed separately in Section IV.

Table 2.1.5 Historic Fisheries and Catch Levels of Sturgeon and Paddlefish in the United States and Canada*

Species	Historic Fishery? (US, CA)	Peak Catch Level (metric tons, year)	Comments
Atlantic sturgeon	US, CA	US: 3,348 mt, 1890+ CA: 120 mt, 1993	***US:*** Delaware Bay supported the largest U.S. fishery during the peak years in the 1880s and 1890s. Following its collapse, the focus of commercial fishing shifted to other river systems during the twentieth century. ***CA:*** St. Lawrence River catch averaged 20–40 mt from 1940 to 1966, then almost no captures from 1967 to 1975, followed by a significant increase to >100 mt in 1988 and 120 mt in 1993.
Gulf sturgeon	US	> 129 mt, 1902	Sporadic data make it difficult to assemble an overall picture of the historic harvest level throughout the species' range; 1902 catch figure includes Florida and Mississippi only. Historic fisheries concentrated in Florida.
Shortnose sturgeon	—	NA/NR	Historic overfishing believed to have impacted populations, primarily through bycatch in Atlantic sturgeon, other fisheries. Separate records on catch not recorded.
Paddlefish	US	1,080 mt, 1899+	Of little commercial interest prior to the late 1800s, although commercial harvest was significant. Became more widely valued as overfishing of Atlantic and lake sturgeon led to the decline of those fisheries.
Shovelnose sturgeon	US	? mt, 20th century	Traditionally perceived as a "trash" fish and often destroyed as a threat to fishing nets. Was harvested in all states on the Mississippi and Missouri rivers during parts of the twentieth century. Not all states kept harvest records, however. Commercial catch in the Upper Mississippi River exceeded 100,000 pounds in 1956 and 1958.
Pallid sturgeon	—	? mt, late 1800s	Believed to have always been a rare species. Caught with lake sturgeon in nineteenth century roe fisheries, but lack of separate records makes estimating historic catch levels impossible.
Alabama sturgeon	US	? mt, late 1800s	Some records exist of a substantial harvest of Alabama sturgeon in the late nineteenth century. In 1898 total commercial catch of shovelnose sturgeon in Alabama was reported as 19,000 kg (Alabama sturgeon had not yet been identified as a separate species). Impossible to determine whether catch was Alabama sturgeon, shovelnose sturgeon, or both.
Lake sturgeon	US, CA	>2,700 mt, ~1885 (US & CA)	Most intense period of fishing began around 1885 in both United States and Canada, with major fisheries on lakes Erie, Huron, Ontario, Superior, Nipissing, Nipigon, Winnipeg, and others. Cumulative catch records for all fisheries not available, but likely to be substantial. Figure of 2,700 metric tons in 1885 is from Lake Erie and Lake Huron fisheries alone.
White sturgeon	US, CA	747 mt, 1885 (Sacramento/San Joaquin River) 2,500 mt, 1892 (Columbia River) 512 mt, 1897 (Fraser River)	Fisheries peaked in different years in major Pacific River systems. The commercial fishery in California's Sacramento/San Joaquin Basin lasted from the 1860s until 1901, then reopened temporarily before closing permanently in 1917. The Columbia River fishery collapsed at the end of the nineteenth century; recovery did not begin until the 1950s. Canada's Fraser River fishery collapsed by 1905, reopened later in the twentieth century, and is again closed.
Green sturgeon	US	? mt, 20th century	Historically not targeted as a food fish or for caviar. Native American subsistence fishing at least since 1900. Columbia River commercial catch averaged 200–500 fish annually from 1941 to 1951; 1,400 fish annually from 1951 to 1971; and 2,000–4,000 fish annually from 1971 to 1990. Columbia River catch of 6,000 fish in 1987 and 4,900 in 1987 were notably high.

* Sources: Compiled by TRAFFIC North America from various species literature and studies, ***in litt***. correspondence, and personal communications. More detailed information and specific references are provided in Section III.

+ Additional Comments: **Atlantic Sturgeon:** From ASMFC (1998b). Secor and Waldman (1999) placed the peak in 1888 at 3,152 metric tons. **Paddlefish:** From Waldman (1999). Russell (1986) reported that the commercial harvest was 1,136 mt in 1897.

USFWS and, in the case of marine species, the National Marine Fisheries Service (NMFS). In Canada, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines national species classifications. North American paddlefish and sturgeon also fall under the auspices of certain international organizations and treaties. The World Conservation Union (IUCN) categorizes the status of species and ecosystems worldwide, including the status of North American species and populations. The role of sturgeon and paddlefish in international trade further places these species under the umbrella of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), as well as the European Union's (EU) Council Regulation (EC) No. 338/97 "on the protection of species of wild fauna and flora by regulating trade therein."

Table 2.1.6 shows how North American acipenseriform species are classified under the ESA, COSEWIC, CITES, IUCN, and the EU. Box 1 explains the categories and criteria used to classify species under these respective legal and scientific regimes.

Challenges/Threats. For the purposes of this report, TRAFFIC did not attempt to comprehensively analyze all of the challenges facing conservation of North America's acipenseriform species. Instead, TRAFFIC conducted a broad review of literature on North American paddlefish and sturgeon, species management and recovery plans, and other sources. This review suggested a general consensus that inter-related issues of habitat alteration (e.g., dams, channelization, dredging, etc.) and degradation of water quality (e.g., pollution, changes in temperature, current velocity, and sedimentation regimes) have affected all native Acipenseriformes. The lingering effects of past overfishing and the unique life history characteristics of sturgeon and paddlefish (i.e., long lives, slow growth, late age at maturation, specific spawning requirements, etc.) are also commonly cited as challenges to the conservation of these species.

Table 2.1.6 Classification of North American Paddlefish and Sturgeon Species Under ESA, COSEWIC, CITES, the IUCN Red List, and EU Annexes*

Species	US/ESA	COSEWIC	CITES	IUCN	EU
Atlantic sturgeon	Not listed+	Not listed	App. II	LR (nt)	B
Gulf sturgeon	Threatened	—	App. II	VU	B
Shortnose sturgeon	Endangered	SC	App. I	VU	A
Paddlefish	Not listed+	Extirpated	App. II	VU	B
Shovelnose sturgeon	Not listed	—	App. II	VU	B
Pallid sturgeon	Endangered	—	App. II	CR	B
Alabama sturgeon	Endangered	—	App. II	CR	B
Lake sturgeon	Not listed	Not listed	App. II+	VU	B
White sturgeon+	Not listed+	SC	App. II	LR(nt)	B
Green sturgeon	Not listed	SC	App. II	VU	B

Key: SC = Special Concern; VU = Vulnerable; LR = Lower Risk (nt/near threatened); CR = Critically Endangered; A = EU Annex A; B = EU Annex B.

* Sources: CITES (2001a), IUCN (2001), Environment Canada (1999, 2000, 2001a, 2001b), USFWS (2002b).

+ Additional Comments: **Atlantic sturgeon:** Designated a Candidate Species for ESA listing in 1991; in 1998 the U.S. Department of Commerce (of which NMFS is a part) decided that listing as threatened or endangered was not warranted at that time. **Paddlefish:** USFWS was petitioned to list the paddlefish under the ESA in 1989; after review, USFWS determined that listing was not warranted (see Section 3.4 for details). **Lake sturgeon:** Listed in Appendix II from 1975 to 1983, then removed from the Appendices until 1997, when re-listed in Appendix II. **White sturgeon:** The Kootenai River subpopulation of the white sturgeon is listed as Endangered by both the United States and Canada and is also considered endangered by IUCN.

Box 1. ESA, COSEWIC, CITES, IUCN Red List, and European Union Annexes*

National laws and international organizations and conventions pertaining to wildlife define and classify species differently according to their own criteria. This report makes frequent reference to these laws and classifications. The following briefly summarizes those most relevant to North American sturgeon and paddlefish.

The Endangered Species Act of 1973 (ESA). The ESA is the primary federal legislation in the United States providing for the protection of threatened and endangered species and the ecosystems upon which they depend. Under the law, species may be listed as either "endangered" or "threatened." Designating a species as ***Endangered*** means that it is in danger of extinction throughout all or a significant portion of its range. ***Threatened*** means a species is likely to become endangered within the foreseeable future. The law is administered by the Interior Department's U.S. Fish and Wildlife Service (USFWS) and the Commerce Department's National Marine Fisheries Service (NMFS). USFWS has primary responsibility for terrestrial and freshwater species, while NMFS jurisdiction includes marine and anadromous species. There is also a list of ***Candidate*** species, for which USFWS has enough information to warrant proposal for listing as threatened or endangered but which have not been proposed for listing.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC). COSEWIC includes members from the Canadian federal, provincial, and territorial governments, as well as nongovernmental representatives. It was created in 1977 to provide a scientifically based evaluation of the national status of Canadian species, subspecies, and separate populations suspected of being at risk. While COSEWIC designations have no legal standing, they are well respected. The legal list of wildlife species at risk in Canada is based on COSEWIC evaluations. Terms and risk categories used by COSEWIC include: ***Extinct***, for species that no longer exist; ***Extirpated***, for species that no longer exist in the wild in Canada but occur elsewhere; ***Endangered***, for species facing imminent extirpation or extinction; ***Threatened***, for species likely to become endangered if limiting factors are not reversed; ***Special Concern***, which applies to species whose characteristics make them particularly sensitive to human activities or natural events; ***Not at Risk***, for species that have been evaluated and found to be not at risk; and ***Data Deficient***, which applies to species for which there is insufficient scientific information to support status designation.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). CITES is an international treaty that came into force in 1975 and as of May 2002 had 158 member nations, known as ***Parties*** to the Convention. CITES provides the international legal framework for a worldwide system of controls on international trade in threatened and endangered wildlife and wildlife products. At present, some 5,000 species of animals and 25,000 species of plants are protected by CITES. Protection for species is provided under the Convention's Appendices, which describe the status of the species and determine what species may be used in international commercial trade. The most endangered species are listed in ***Appendix I***, which includes all species threatened with extinction that are or may be affected by trade. Commercial trade is not permitted for these species, and other trade for purposes such as scientific research is strictly controlled through import and export permits. ***Appendix II*** species are those that are not rare or endangered at present but could become so if trade is not regulated; international trade in such species requires the issuance of a CITES export permit by the exporting country. ***Appendix III*** species are not endangered but are subject to

continued on next page

regulation within the listing nation for the purposes of preventing or restricting exploitation, and, as requested, promoting the cooperation of other parties in the control of trade. Appendix III requires the issuance of an export permit by the listing country, or a Certificate of Origin from all other parties. Any Party to CITES may unilaterally state that it will not abide by the provisions of the Convention relating to trade in a particular species listed in the Appendices. Such statements are ***Reservations*** made in accordance with relevant Articles of CITES. For species included in Appendix I or II, there are restrictions on when a reservation may be entered.

IUCN Red List 2000. The World Conservation Union (IUCN) periodically publishes the ***Red List***, a comprehensive inventory of the global conservation status of plant and animal species, to convey the urgency and scale of conservation problems to the public and policy makers, and to motivate global action to reduce species extinctions. First conceived in 1963, the Red List system set a standard for species listing and conservation assessment efforts. Most recently, Red Lists were published in 1996 and 2000, using a set of scientific criteria relevant to evaluating the extinction risk of thousands of species and subspecies. Taxa are divided into eight categories. ***Extinct*** refers to a taxon when there is no reasonable doubt that the last individual has died. ***Extinct in the Wild*** includes taxa known to survive only in cultivation, captivity, or as a naturalized population (or populations) outside the past range. ***Critically Endangered*** taxa are those facing an extremely high risk of extinction in the wild in the immediate future. ***Endangered*** refers to taxa not critically endangered but facing a very high risk of extinction in the wild in the near future. ***Vulnerable*** pertains to taxa not critically endangered or endangered but facing a high risk of extinction in the wild in the medium-term future. ***Lower Risk*** applies to taxa that upon evaluation do not satisfy the criteria for any of the categories critically endangered, endangered, or vulnerable (there are three sub-categories: *Conservation Dependent*, *Near Threatened*, and *Least Concern*). ***Data Deficient*** applies to taxa when there is inadequate information to make a direct or indirect assessment of the species' risk of extinction based on distribution and/or population status. ***Not Evaluated*** refers to taxa that have not yet been assessed against the criteria.

The European Union. In December 1996, the Council of the European Union adopted Council Regulation (EC) No. 338/97 "on the protection of species of wild fauna and flora by regulating trade therein." The Regulation established a set of annexes generally consistent with CITES. ***Annex A*** contains species listed in CITES Appendix I for which the EU Member States have not entered a reservation, as well as species that are or may be in demand in the EU or international trade and are either threatened with extinction or so rare that any trade would imperil their survival. ***Annex B*** contains: (1) species listed in CITES Appendix II (other than those listed in Annex A) for which the Member States have not entered a reservation, and species listed in CITES Appendix I for which a reservation has been entered; (2) species not listed in Appendices I or II that are subject to levels of international trade that might not be compatible with their survival, the survival of populations in certain countries, or the maintenance of the total population at a level consistent with the role of the species in the ecosystems in which they occur; and (3) species whose listing is for reasons of similarity in appearance to other species listed in Annex A or B, to ensure the effectiveness of controls on trade. ***Annex C*** contains species listed in CITES Appendix III that are imported into the EU for which the Member States have not entered a reservation, as well as species listed in CITES Appendix II for which a reservation has been entered. ***Annex D*** contains species not listed in Annexes A to C that are imported into the EU in numbers that warrant monitoring, and species listed in CITES Appendix III for which a reservation has been entered.

* Sources: CITES (2000), IUCN (2000), COSEWIC (2001), European Union (2001), USFWS (2001a, 2001b).

Table 2.1.7 lists those major challenges or threats to North American Acipenseriformes that are discussed in more detail in the species descriptions in Section III.

2.2 Management and Regulation in the United States and Canada

Because of their broad distribution and highly migratory nature, North American Acipenseriformes fall under the purview of myriad federal, state, provincial, and international agencies, commissions, and other management authorities. For example, anadromous species such as the Atlantic sturgeon, shortnose sturgeon, Gulf sturgeon, white sturgeon, and green sturgeon might spend parts of their lives in state or provincially managed waters and parts in federally managed waters, including the Exclusive Economic Zones (EEZ) that extend up to 200 nautical miles (370 kilometers) from the coastline. Freshwater species such as the paddlefish, shovelnose sturgeon, pallid sturgeon, and lake sturgeon are also migratory in the river systems they inhabit, and may regularly cross jurisdictional lines during their life cycles.

There has been an attempt to coordinate and rationalize an overall strategy for paddlefish and sturgeon management and conservation in the United States, represented in the National Paddlefish and Sturgeon Steering Committee. There are also established inter-jurisdictional and international bodies and agreements covering certain geographic regions and the species that fall within them, such as the Atlantic States Marine Fisheries Commission, Gulf States Marine Fisheries Commission, Great Lakes Fisheries Commission, Columbia River Compact, and Mississippi Interstate Cooperative Resource Association. Some U.S. states have also joined voluntarily to cooperate in the management of certain populations (e.g., the Yellowstone-Sakakawea Paddlefish Stock Management Plan between Montana and North Dakota). However, the number of species involved, their varying status and needs, and the sheer number of political and bureaucratic entities involved make it virtually impossible for there to be any centralized management authority or strategy.

Table 2.1.7 Major Challenges/Threats to North American Acipenseriformes*

Species	Habitat Degradation/ Restricted Range	Pollution/ Water Quality	Historic Over-fishing	Life History Characteristics/ Limitations	Non-indigenous Disease or Competition	Rarity/Lack of Natural Reproduction	Other
Atlantic sturgeon	X	X	X	X	X		X+
Gulf sturgeon	X	X	X	X	X		
Shortnose sturgeon	X	X	X+	X	X		
Paddlefish	X	X	X				X+
Shovelnose sturgeon	X	X					X+
Pallid sturgeon	X	X				X	X+
Alabama sturgeon	X	X	X			X	
Lake sturgeon	X	X	X				
White sturgeon	X	X	X			X+	
Green sturgeon	X	X					X+

* Sources: Compiled by TRAFFIC North America from various species literature and studies, *in litt.* correspondence, and personal communications. More detailed information and specific references are provided in Section III.

+ Additional Comments: **Atlantic sturgeon:** Bycatch in other fisheries (see Section 3.1 for details). **Shortnose sturgeon:** Likely as bycatch in other fisheries (Atlantic sturgeon, shad, others—see Section 3.3 for details). **Paddlefish:** Illegal catch and trade (see Section 3.4 for details). **Shovelnose sturgeon:** Illegal catch and trade (see Section 3.5 for details). **Pallid sturgeon:** Hybridization (see Section 3.6 for details). **White sturgeon:** Particularly Kootenai River subpopulation and other fragmented subpopulations in Columbia River in the United States; Kootenay, Nechako, and upper Columbia River populations in Canada (see Section 3.9 for details). **Green sturgeon:** Much remains unknown or not well documented about the green sturgeon.

Instead, the ways that acipenseriform species are legally classified, and the purposes for which they are managed, vary widely among the states and provinces that they inhabit, reflecting the individual circumstances in each specific jurisdiction. To give a very broad example, the paddlefish may be classified as threatened or endangered in one state, and thereby protected from fishing, but considered abundant in a neighboring state, which therefore allows commercial and sport fishing of the species. In the case of U.S. species that are listed as threatened or endangered at the federal level under the ESA, management regimes further fall under the provisions and strictures of that law.

Section IV of this report describes the management structures in place regarding each of North America's acipenseriform species at the federal, state, and provincial levels. Table 2.2.1 below provides a summary overview of how the various species are legally classified at the state and provincial levels in the United States and Canada, and whether or not commercial and/or sport fishing are allowed.

Table 2.2.1 State and Provincial Classifications/Commercial and Sport Fishing for Paddlefish and Sturgeon in the United States and Canada (45 U.S. States and 10 Canadian Provinces)*

Province/State	AtlS	GlfS	ShnS	Pd	ShvS	AlS	PS	LS	WS	GrS
Alberta	—	—	—	—	—	—	—	SF+	—	—
British Columbia	—	—	—	—	—	—	—	—	IM+	CI
Manitoba	—	—	—	—	—	—	—	CL+	—	—
New Brunswick	CF, SF	—	—	—	—	—	—	—	—	—
Newfoundland	CL	—	—	—	—	—	—	—	—	—
Nova Scotia	CL	—	—	—	—	—	—	—	—	—
Ontario	—	—	—	EX	—	—	—	CF, SF	—	—
PEI	CL	—	—	—	—	—	—	—	—	—
Quebec	CF, SF	—	—	—	—	—	—	CF, SF	—	
Saskatchewan	—	—	—	—	—	—	—	CL+	—	—
Alabama	—	TH	—	CL	CL	PR	—	EX	—	—
Alaska	—	—	—	—	—	—	—	—	CF	CF
Arkansas	—	—	—	CF, SF	CF, SF	—	EN	EX	—	—
California	—	—	—	—	—	—	—	—	SF	SC, SF
Connecticut	TH	—	EN	—	—	—	—	—	—	—
Delaware	EN	—	CL	—	—	—	—	—	—	—
Florida	SC	SC+	EN	—	—	—	—	—	—	—
Georgia	CL	SC+	EN	EX	—	—	—	SC+	—	—
Idaho	—	—	—	—	—	—	—	—	CL+	—
Illinois	—	—	—	CF, SF	CF, SF	—	EN	EN	—	—
Indiana	—	—	—	CF, SF	CF, SF	—	EN	EN	—	—
Iowa	—	—	—	SF	CF, SF	—	EN	EN	—	—
Kansas	—	—	—	SF	SF	—	EN	CL+	—	—
Kentucky	—	—	—	CF, SF	CF, SF	—	EN	CL	—	—
Louisiana	—	TH	—	CL	CL	—	EN	EX	—	—
Maine	CL	—	CL	—	—	—	—	—	—	—
Maryland	CL	—	EN	EX	—	—	—	—	—	—
Massachusetts	EN	—	EN	—	—	—	—	—	—	—
Michigan	—	—	—	—	—	—	—	TH, SF	—	—
Minnesota	—	—	—	TH	SF	—	—	SC, SF	—	—
Mississippi	—	EN	—	CF, SF	CL	EN	EN	CL	—	—
Missouri	—	—	—	CF, SF	CF, SF	—	EN	EN	—	—
Montana	—	—	—	SC, SF	SF	—	EN	—	CL+	—
Nebraska	—	—	—	SF	SF	—	EN	TH	—	—
New Hampshire	CL	—	EN	—	—	—	—	—	—	—
New Jersey	CL	—	EN	—	—	—	—	—	—	—
New Mexico	—	—	—	—	EX	—	—	—	—	—
New York	CL	—	EN	EX+	—	—	—	TH	—	—
North Carolina	SC	—	EN	EN+	EX	—	—	SC+	—	—

Table 2.2.1 State and Provincial Classifications/Commercial and Sport Fishing for Paddlefish and Sturgeon in the United States and Canada (45 U.S. States and 10 Canadian Provinces)* *continued*

Province/State	AtlS	GlfS	ShnS	Pd	ShvS	AlS	PS	LS	WS	GrS
North Dakota	—	—	—	SF	—	—	EN	—	—	
Ohio	—	—	—	TH, SF	EN	—	—	EN	—	—
Oklahoma	—	—	—	SF	SF	—	—	—	—	—
Oregon	—	—	—	—	—	—	—	—	CF, SF	SF
Pennsylvania	TH	—	EN	CL+	EX	—	—	EN	—	—
Rhode Island	SH	—	CL	—	—	—	—	—	—	—
South Carolina	CL	—	EN	—	—	—	—	—	—	—
South Dakota	—	—	—	SF	CL	—	EN	CL+	—	—
Tennessee	—	—	—	CF, SF	CF, SF	—	EN	EN	—	—
Texas	—	—	—	TH	TH	—	—	—	—	—
Vermont	—	—	—	—	—	—	—	EN	—	—
Virginia	SC	—	EN	EN+	—	—	—	—	—	—
Washington	—	—	—	—	—	—	—	—	CF, SF	SF
West Virginia	—	—	—	CI	CL	—	—	EX	—	—
Wisconsin	—	—	—	TH	CF, SF	—	—	WA, SF	—	—
Wyoming	—	—	—	—	SF	—	—	—	—	—

Key: AtlS = Atlantic sturgeon; GlfS = Gulf sturgeon; ShnS = Shortnose sturgeon; Pd = Paddlefish; ShvS = Shovelnose sturgeon; AlS = Alabama sturgeon; PS = Pallid sturgeon; LS = Lake sturgeon; WS = White sturgeon; GrS = Green sturgeon; EN = Endangered; TH = Threatened; IM = Imperiled; CI = Critically Imperiled; EX = Extirpated; SC = Species of Special Concern; SH = State Historical (documented for state in last 100 years but not currently known to occur); CF = Commercial Fishery; SF = Sport Fishery (in many states/provinces species classified as Game Fish); CL = Species not legally classified as threatened, endangered or at risk, but commercial and sport fishing closed; PR = Protected nongame species; WA = Watch List.

* Sources: Compiled by TRAFFIC North America from various species literature and studies, *in litt.* correspondence, and personal communications. More detailed information and specific references are provided in Section IV.

+ Additional Comments: **Alberta:** Zero catch limit in the North Saskatchwan River (catch-and-release only); Sport catch allowed in the South Saskatchewan River and its tributaries. **British Columbia:** Three white sturgeon populations in British Columbia (the Nechako, upper Columbia, and Kootenay populations) designated as Critically Imperiled by the province. **Manitoba:** Catch-and-release fishing allowed in many rivers, as is aboriginal subsistence fishing. **Newfoundland:** Atlantic sturgeon may be present in marine waters, but no commercial or sport fishery. **Saskatchewan:** Has commercial quota, but province imposed a moratorium on catch in 1996. Sport angling is catch-and-release only. **Florida:** State does not list subspecies separately from Atlantic sturgeon, but notes federal Threatened status. **Georgia:** Gulf and lake sturgeon listed as Species of Special Concern based on historical occurrence. No reports of species in recent years, but may still be extant. **Idaho:** Catch-and-release fishing only in Snake River. The Kootenai River subpopulation is listed as Endangered under the ESA. **Kansas:** No directed commercial fishing for lake sturgeon, but those who catch them incidentally in other fisheries may keep them. No sport fishery. **Montana:** Kootenai River subpopulation, listed as Endangered under the ESA. **New York:** Natural paddlefish population extirpated. Recovery through stocking underway. **North Carolina:** Paddlefish listed based on historical occurrence. No reports of species in recent years, but may still be extant. Lake sturgeon listed as Species of Special Concern, although apparently extirpated from the state. **Pennsylvania:** Natural paddlefish population extirpated. Recovery through stocking underway; population status/recovery progress undetermined to date. **South Dakota:** Lake sturgeon not legally classified as Threatened or Endangered, but is on a state list of rare, threatened or endangered animals. State prohibits catch of any sturgeon species. **Virginia:** Paddlefish likely extirpated, but listed as Endangered to protect possible extant fish.

2.3 Legal and Illegal Trade

North American paddlefish and sturgeon species have a long history in commercial trade. Traditionally, the majority of the markets for their products—caviar in particular—have been within North America. Unfortunately, historic overfishing during periods of high demand and prices for caviar led at various times to dramatic population declines and the collapse of fisheries for the Atlantic sturgeon, Gulf sturgeon, lake sturgeon, white sturgeon, and other species taken incidentally as bycatch. Similarly, demand for paddlefish roe for caviar has spiked and declined in cycles over the past century or more, leading to years of heavy fishing pressure followed by years of relative inattention. Given the ready availability and preference for the caviar of Caspian Sea sturgeon in recent decades, trade pressure on North American species remained relatively low. Recent developments in the Caspian Sea fisheries, however, indicate that this circumstance is likely coming to an end. In legal markets, prices for roe from North American species are rising, possibly because of anticipation of the further decline or even complete collapse of Caspian Sea production. Price increases are likely in illegal markets as well. In a more ominous development, law enforcement authorities are beginning to detect caviar from North American species mislabeled and sold fraudulently as Caspian Sea product.

Table 2.3.1 Commercial Trade of Native Acipenseriformes in the United States and Canada (2002)*

Species	United States			Canada		
	Trade from Domestic Stocks Legal?	Export Trade Legal?	Import Trade Legal?	Trade from Domestic Stocks Legal?	Export Trade Legal?	Import Trade Legal?
Atlantic sturgeon	No	No	Yes[1]	Yes	Yes	Yes[2]
Gulf sturgeon	No	No	No	—	—	—
Shortnose sturgeon	No	No	No	No	No	No
Paddlefish	Yes	Yes	Yes[2]	—	—	Yes
Shovelnose sturgeon	Yes	Yes	Yes[2]	—	—	Yes
Pallid sturgeon	No	No	No	—	—	—
Alabama sturgeon	No	No	No	—	—	—
Lake sturgeon	No	No	Yes[1]	Yes	Yes	Yes[2]
White sturgeon	Yes	Yes[3]	Yes[2]	No	No	Yes[1]
Green sturgeon	Yes	Yes[2]	Yes	No	No	Yes[1]

* Source: TRAFFIC summary of species trade status, detailed in Section V of this report.

Additional Comments:

[1] Subject to specific prohibitions or restrictions in certain states or provinces.

[2] Legal, but little to no actual trade recorded.

[3] Meat and caviar only; commercial trade in live white sturgeon prohibited since 1999.

Section V of this report discusses the current status of North American Acipenseriformes in legal trade, both domestically and internationally, as well as what is known about illegal trade in North American caviar. Table 2.3.1 provides a very broad overview of legal trade in North American sturgeon and paddlefish.

2.4 Hatcheries and Commercial Aquaculture

Captive rearing of North American acipenseriform species takes two basic forms. One involves captive propagation of sturgeon and paddlefish in government or government-sponsored hatcheries for purposes of species recovery, restoration, stocking or research. The other involves commercial aquaculture, usually by private interests, to produce caviar, meat, or live fish for the commercial market. As is discussed in Section VI of this report, both activities carry potential benefits for the conservation of native acipenseriform stocks. Captive propagation can assist in the recovery or reintroduction of endangered species, augment existing sturgeon or paddlefish stocks, and provide a means to better understand the biology and ecology of these fish. Commercial aquaculture may provide an alternative source of roe to wild-caught fish. However, both practices also carry potential risks or drawbacks, for example genetic dilution of wild stocks, introduction of non-native diseases, or, in the case of commercial aquaculture, an opportunity for the illegal laundering of roe from wild paddlefish and sturgeon populations.

Table 2.4.1 provides a very broad summary of U.S. states and Canadian provinces with active or recent captive propagation programs, stocking efforts, and commercial aquaculture operations. Some of these initiatives involve federal agencies, some have been undertaken by state or provincial authorities, and some are private ventures. For purposes here, the table shows the presence of commercial aquaculture in jurisdictions where there are licensed operations. As is described in more detail in Section VI, in some jurisdictions it is not known whether any or all of the private operations licensed to rear paddlefish or sturgeon are actively engaged in commercial aquaculture. It should also be noted that commercial aquaculture of paddlefish is legal but not closely monitored in several U.S. states. As Section VI explains, it is therefore possible that there are commercial operations rearing paddlefish in more states than are indicated in the table.

Table 2.4.1 Captive Propagation and Commercial Aquaculture of North American Sturgeon and Paddlefish Species in the United States and Canada (45 U.S. States and 10 Canadian Provinces)*

Province/State	AtlS	GlfS	ShnS	Pd	ShvS	AlS	PS	LS	WS	GrS
Alberta	—	—	—	—	—	—	—	—	—	—
British Columbia	—	—	—	—	—	—	—	—	CP, AQ	—
Manitoba	—	—	—	—	—	—	—	CP, ST	—	—
New Brunswick	AQ	—	—	—	—	—	—	—	—	—
Newfoundland	—	—	—	—	—	—	—	—	—	—
Nova Scotia	—	—	—	—	—	—	—	—	—	—
Ontario	—	—	—	—	—	—	—	AQ	—	—
PEI	—	—	—	—	—	—	—	—	—	—
Quebec	—	—	—	—	—	—	—	—	—	—
Saskatchewan	—	—	—	—	—	—	—	ST	—	—
Alabama	—	—	—	—	—	CP	—	—	—	—
Alaska	—	—	—	—	—	—	—	—	—	—
Arkansas	—	—	—	—	—	—	—	—	—	—
California	—	—	—	—	—	—	—	—	AQ	—
Connecticut	—	—	—	—	—	—	—	—	—	—
Delaware	—	—	—	—	—	—	—	—	—	—
Florida	AQ	CP	CP	—	—	—	—	—	—	—
Georgia	—	CP	CP, ST	AQ	—	—	—	CP	—	—
Idaho	—	—	—	—	—	—	—	—	CP, AQ	—
Illinois	—	—	—	AQ	AQ	—	—	—	—	—
Indiana	—	—	—	—	—	—	—	—	—	—
Iowa	—	—	—	—	—	—	—	—	—	—
Kansas	—	—	—	CP, ST	—	—	—	—	—	—
Kentucky	—	—	—	AQ	—	—	—	—	—	—
Louisiana	—	CP	—	CP, ST	CP	—	CP, ST	—	—	—
Maine	—	—	—	—	—	—	—	—	—	—
Maryland	ST	—	—	—	—	—	—	—	—	—
Massachusetts	CP	—	—	—	—	—	—	—	—	—
Michigan	—	—	—	—	—	—	—	CP, ST	—	—
Minnesota	—	—	—	—	—	—	—	CP, ST, AQ	—	—
Mississippi	—	—	—	CP	—	—	—	—	—	—
Missouri	—	—	—	CP, AQ	—	—	CP, ST	CP, ST	—	—
Montana	—	—	—	CP	—	—	ST	—	—	—
Nebraska	—	—	—	—	—	—	ST	—	AQ	—
New Hampshire	—	—	—	—	—	—	—	—	—	—
New Jersey	—	—	—	—	—	—	—	—	—	—
New Mexico	—	—	—	CP	—	—	—	—	—	—
New York	ST	—	—	CP, ST	—	—	—	CP, ST	—	—
North Carolina	—	—	—	—	—	—	—	—	—	—
North Dakota	—	—	—	—	CP	—	CP, ST	—	—	—
Ohio	—	—	—	AQ	CP	—	—	CP	—	—
Oklahoma	—	—	—	CP, ST	—	—	—	— —		—
Oregon	—	—	—	—	—	—	—	—	—	—
Pennsylvania	CP	—	—	CP, ST	—	—	—	—	—	—
Rhode Island	—	—	—	—	—	—	—	—	—	—
South Carolina	CP	—	CP, ST	—	—	—	—	—	—	—
South Dakota	—	—	—	CP, ST	CP	—	CP, ST	—	—	—
Tennessee	—	—	—	AQ	—	—	—	ST	—	—
Texas	—	—	—	CP, ST	—	—	—	—	—	—
Vermont	—	—	—	—	—	—	—	CP	—	—
Virginia	CP	—	—	—	—	—	—	—	—	—
Washington	—	—	—	—	—	—	—	—	CP	—
West Virginia	—	—	—	ST	ST	—	—	—	—	—
Wisconsin	—	—	—	—	—	—	—	CP, ST	—	—
Wyoming	—	—	—	—	ST	—	—	—	—	—

Key: AtlS = Atlantic sturgeon; GlfS = Gulf sturgeon; ShnS = Shortnose sturgeon; Pd = Paddlefish; ShvS = Shovelnose sturgeon; AlS = Alabama sturgeon; PS = Pallid sturgeon; LS = Lake sturgeon; WS = White sturgeon; GrS = Green sturgeon; CP = Captive Propagation; AQ = Commercial Aquaculture; ST = Stocking.

* Sources: Compiled by TRAFFIC North America from various literature, in litt. correspondence, and personal communications. More detailed information and specific references are provided in Section VI.

III. Species Summaries

North American Acipenseriformes occur in marine, estuarine, and freshwater ecosystems. The ranges of several species overlap; however, different life history characteristics and seasonal habitat use patterns have largely averted direct competition among them. Atlantic and shortnose sturgeons inhabit rivers, estuaries, and marine waters along the Atlantic coast. The Gulf sturgeon is endemic to U.S. coastal rivers and near-shore waters along portions of the central and eastern Gulf of Mexico. The paddlefish, shovelnose sturgeon, pallid sturgeon, and Alabama sturgeon occur in interior freshwater ecosystems, primarily within the Mississippi and Missouri river drainages. Lake sturgeon inhabit both the rivers and lakes of southern Canada and the Mississippi and Missouri river systems. White sturgeon and green sturgeon are found in rivers, estuaries, and marine waters along the Pacific coast.

There is ongoing debate about whether some North American sturgeons are truly separate species, or merely subspecies or variations of other species. Such debate particularly concerns the pallid and Alabama sturgeons, and their relationship to the shovelnose sturgeon. TRAFFIC does not attempt to address such issues herein, as they primarily encompass discussions regarding morphology and genetics that fall outside the scope of this report. The species, subspecies, and sub-populations included here are those recognized under U.S. or Canadian law, or treated distinctly by federal, state, or provincial fisheries agencies for management purposes.

Historical accounts suggest that paddlefish and almost all North American sturgeon species were once relatively abundant. The exception is the pallid sturgeon, which is believed to have always been rare. Such is not the case today, when only a few species have populations that can be considered relatively abundant, and even then often only in parts of their present range. For example, portions of some Pacific river systems and their tributaries may have fairly significant populations of white sturgeon, while other segments of the same rivers now contain only isolated and threatened sub-populations. There has also been considerable discussion about the situation of the paddlefish and shovelnose sturgeon in parts of their ranges in the Mississippi and Missouri river systems.

The following section condenses known information on each of the North American acipenseriform species, including their historic range and current distribution, ecology and habitat, historic catch levels, present conservation status, and threats or challenges to continued survival. The amount of information and level of detail available for each species vary, particularly regarding historic range and catch. This is because recorded data on some species are sketchy, and often consist largely of anecdotal accounts. Even the historical presence of some acipenseriform species in certain river systems cannot be definitively confirmed. As the species accounts herein show, the same can be said of whether some Acipenseriformes are present or absent today in some waters they are believed to have once inhabited. Resolving the true status of several species will require further research.

3.1 Atlantic Sturgeon *(Acipenser oxyrinchus oxyrinchus)*

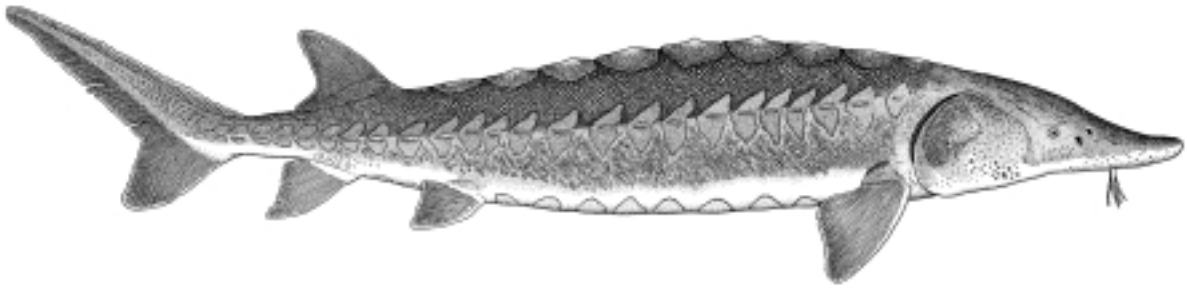


Illustration by Paul Vecsei

Sometimes referred to as the black sturgeon, common sturgeon, or sea sturgeon, the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is one of two subspecies of *A. oxyrinchus* present in North America, the other being the Gulf sturgeon (*A. o. desotoi*). The Atlantic sturgeon is a large, anadromous fish native to the Atlantic ocean and bays and rivers along the eastern coast of North America. Once found in abundance, the species is now considered rare in many rivers and coastal waters throughout its historic range. A primary cause for the Atlantic sturgeon's decline is believed to be past overfishing (Atlantic States Marine Fisheries Commission [ASMFC] 1998a, 1998b). As fishing pressure shifted from state to state during various decades over the past century or more, individual populations declined in succession, and the species has proven as yet unable to rebound. Although the U.S. population of Atlantic sturgeon was proposed for listing under the Endangered Species Act in the 1990s, in 1998 the federal government concluded that listing was not warranted at that time (Field et al. 1999).

Historic Range and Current Distribution

The historic range of the Atlantic sturgeon covered most of the eastern seaboard of North America, from Hamilton Inlet in Labrador, Canada to the St. Johns River in Florida. Although the species' overall range remains relatively constant to this day, Atlantic sturgeon have been extirpated locally from some rivers.

Because the Atlantic sturgeon is a highly migratory, anadromous species, there are two ways to measure its range. One method regards where the species is believed to be present at least occasionally, while the other pertains to those rivers in which it spawns. For example, while the Atlantic sturgeon has been reported as far north as Labrador, it is not known if spawning ever occurred in any river there. In addition, the extensive migration of sub-adult Atlantic sturgeon means that the presence of juveniles in a river does not necessarily provide evidence of spawning (National Marine Fisheries Service and U.S. Fish and Wildlife Service [NMFS/USFWS] 1998). Therefore, in terms of overall distribution, the range of the Atlantic sturgeon covers almost the entire eastern seaboard of North America from Labrador to Florida. But in terms of reproduction, the species' known historic spawning range consists of a distinct subset of rivers between Newfoundland in the north and Florida in the south.

In 1998, responding to a petition from the Biodiversity Legal Foundation to list the Atlantic sturgeon as threatened or endangered and designate critical habitat, NMFS and USFWS conducted a status review of the species to determine if protection under the Endangered Species Act was warranted (NMFS/USFWS 1998). One of the steps in that review was an examination of the distribution and abundance of the species. Much of the information presented here summarizes the findings of that review, as well as the findings of other studies, as cited. Figure 1 shows the overall range of the Atlantic sturgeon.

Unfortunately, the aforementioned review found comprehensive information on current or

historic abundance of Atlantic sturgeon lacking for most river systems. Overfishing in the late 1800s led to a significant decline in the abundance of the species throughout its range, and habitat degradation from dams, dredging, and other human activities also impacted stocks, especially in the early to mid-1900s. Because these developments took place in the absence of any concrete scientific baseline data on the species, it proved difficult to precisely quantify the extent of the Atlantic sturgeon's decline. Also, available data were largely derived from studies directed at other species, and primarily provided evidence of absence or presence rather than abundance (NMFS/USFWS 1998). Consequently there is an incomplete body of research on the historic presence of Atlantic sturgeon in the United States and Canada, including the exact number of rivers that may have once had spawning populations.

In Canada, Atlantic sturgeon have historically been reported as far north as the lower George River in Ungava Bay and Hamilton Inlet in Labrador. The species is currently found in Quebec in the Gulf of St. Lawrence from the

Figure 1 Historic Atlantic Sturgeon Range

Blanc Sablon on the Quebec side of the Strait Belle Isle, in the St. Lawrence River up to Trois Rivières, and occasionally further upriver at Sorel. Atlantic sturgeon have also been captured on the Gulf of St. Lawrence shore in Newfoundland; in the Mirimichi River, New Brunswick; and at Cheticamp, Aspy Bay, Canso Straits, and Halifax in Nova Scotia. In the Bay of Fundy, Atlantic sturgeon were found in studies during the 1960s to be abundant in the Saint John River, New Brunswick, and were reported in the Minas basin, Passamaquoddy Bay, and the Avon River (NMFS/USFWS 1998; Anon. 2001a).

Unfortunately, very little sampling has been done to document the spawning grounds or breeding behavior of Atlantic sturgeon in Canadian rivers. In the St. Lawrence River, spawning is believed to occur in deep pools below waterfalls in tributaries, including the Batican River and Riviere aux Outardes (Anon. 2001a). Interviews cited in the NMFS/USFWS survey found it likely that Atlantic sturgeon spawned in the Mirimichi, Shubenacadie, and La Have rivers. It is also believed that the species probably spawned historically in the Annapolis River in Nova Scotia (NMFS/USFWS 1998).

In the United States, Atlantic sturgeon were present historically in approximately 34 rivers, from the Penobscot in Maine to the St. Johns in Florida; it is unknown how many of those rivers supported spawning. The current range may have contracted slightly, reaching from the Kennebec River, Maine, (absence from the Penobscot River is not certain) to the Satilla River, Georgia. Atlantic sturgeon have been reported as extant in 32 U.S. rivers, although spawning may now occur in only as many as 14 of these (NMFS/USFWS 1998).

State-by-state, available information on Atlantic sturgeon in the United States shows continuing uncertainty about its abundance or even its presence in some river systems.

Maine: The historic northern limit of the U.S. Atlantic sturgeon population was believed to be Maine's Penobscot River. In 1994 and 1995, a sampling effort by state authorities to determine the presence of shortnose sturgeon in the river failed to capture either shortnose or Atlantic sturgeon. Although no recent evidence of Atlantic sturgeon presence was found, because of the mesh sizes used in the sampling, the limited focus of the effort, and the presence of suitable habitat in the river, the possibility that a small population may exist cannot be ruled out (NMFS/USFWS 1998).

The estuarial complex of Maine's Kennebec, Androscoggin, and Sheepscot rivers is the only system in New England exhibiting current evidence of Atlantic sturgeon spawning. The species was believed to be historically abundant in the Kennebec River and its tributary the Androscoggin. A series of sampling efforts and surveys using gill nets and trawls in the 1980s and 1990s captured both adult male sturgeon expressing milt and sub-adults in the Kennebec River and its tidal freshwater tributaries and mid-estuary, providing evidence that a spawning population was present. While as of the time of this report studies had not been conducted to determine whether Atlantic sturgeon continue to spawn in the Androscoggin River, sub-adults have been captured in the Sheepscot River, which is believed to serve as a nursing area for Kennebec River sturgeon. Atlantic sturgeon may also use the estuaries of smaller Maine rivers during summer months, although most of these coastal rivers are not suitable for spawning populations (NMFS/USFWS 1998).

New Hampshire, Massachusetts, Rhode Island, and Connecticut: Atlantic sturgeon inhabit several rivers in these states, but there is no contemporary evidence of spawning populations. For example, while a few Atlantic sturgeon have been captured in the Piscataqua River/Great Bay Estuary system in New Hampshire, these appear to be isolated events. The species is found only rarely in tidal waters of the state, although it is believed likely that sub-adults use the Great Bay Estuary as a nursery habitat (NMFS/USFWS 1998; Bruce Smith, Marine Biologist, New Hampshire Department of Fish and Game, in litt. to Rosemarie Gnam, USFWS/OMA, August 15, 2000). Similarly, there are historic and recent reports of adult Atlantic sturgeon being captured or found dead in the Merrimack River (New Hampshire and Massachusetts). While studies using intensive gill net surveys during the late 1980s provided no evidence of a spawning population, capture and sonic tracking of sub-adults indicated that the river is used as a nursery ground. In the Taunton River

(Massachusetts and Rhode Island), Connecticut River (Massachusetts and Connecticut), Thames River (Connecticut), and Housatonic River (Connecticut), there are historic reports of spawning populations dating to the 1700s, and of use of Atlantic sturgeon by Native Americans. However, in recent times there is no evidence of spawning, and stocks of Atlantic sturgeon native to these river systems are believed to be extirpated. There are reports of sub-adults being captured in all of these rivers, indicating that while spawning populations may no longer be present, the river systems and their estuaries continue to be used as nursery areas (NMFS/USFWS 1998).

New York: It is believed that New York's Hudson River was historically important for spawning. The Hudson supported subsistence and commercial fisheries for Atlantic sturgeon during Colonial times, and legal catch continued sporadically through 1997. However, no data on abundance of juvenile sturgeon was available before the 1970s. Two later studies indicated that the river continues to serve as a spawning ground, but there are indications of a decline. Whereas an estimate for the 1976 year class ranged from 14,500 to 36,000 individuals (mean of 25,000), a Cornell University sample estimated that there were 9,529 age 0 Atlantic sturgeon in the estuary in 1994. Because the New York Department of Environmental Conservation stocked 4,929 Atlantic sturgeon marked age 0 in October 1994, by extrapolation 4,600 fish were of wild origin, a significant decline from the 1976 year class. Available data from mark/recapture studies, bycatch from the commercial gill net fishery, and utilities sampling[1] indicated that the greatest decline appeared to occur in the middle to late 1970s, followed by a secondary drop in the late 1980s. The Hudson River supported spawning as recently as 1997, although efforts to secure mature adult Atlantic sturgeon in that year resulted in the capture of only males, unlike in previous years when both males and females were found (NMFS/USFWS 1998).

New Jersey, Delaware, and Pennsylvania: The Delaware River, which flows through these three states into the Delaware Bay, may have supported the largest historical stock of Atlantic sturgeon of any coastal river system. Possible spawning grounds were reported as far north as Bordentown, New Jersey, just below Trenton, and juveniles were once considered a nuisance bycatch in the American shad fishery. As with the Hudson River, recent studies and surveys indicate that the species has declined sharply from historical levels, which may be attributable to the fact that much of the Atlantic sturgeon fishery concentrated in the Delaware River and Bay at the end of the nineteenth century (ASMFC 1998b; NMFS/USFWS 1998; Secor and Waldman 1999). Whereas Secor and Waldman (1999) calculated that female abundance of Atlantic sturgeon in 1890 may have been as high as 180,000 (extrapolated from estimates of biomass, male/female catch biomass ratio, and mean female weight), NMFS/USFWS (1998) reported that population estimates based on mark and recapture of immature Atlantic sturgeon declined from a high of 5,600 in 1991 to less than 1,000 in 1995. Despite the high value of caviar, no commercial fishery developed in recent periods when catch was legal, suggesting a very low abundance of spawning stock. The continued presence of adult sturgeon and juveniles aged one year or younger indicates that the Delaware River and Bay continue to serve as a spawning ground, although numbers are believed to have declined during the 1990s (NMFS/USFWS 1998).

The Chesapeake Bay and tributaries in Pennsylvania, Maryland, and Virginia: This system comprises another complex of rivers and estuaries where Atlantic sturgeon were historically common. Important rivers with historic and modern reports of sturgeon spawning grounds or presence include the Potomac, Rappahannock, York, James, Susquehanna, and Nanticoke. Along with fish of hatchery origin, the capture of numerous juvenile young-of-the-year wild or age 1+ Atlantic sturgeon from the lower James and York rivers in an interagency reward program from 1996 to 1998 indicate that spawning may have taken place as recently as 1996 or 1997 in the lower Chesapeake Bay, and most of the Bay and several major tributaries are used as nursery habitat (NMFS/USFWS 1998).

[1] Hudson River Valley utilities conduct extensive river-wide fisheries surveys to estimate impacts of power plant operations.

North Carolina: Atlantic sturgeon were historically abundant in most of North Carolina's coastal rivers and estuaries, including the Roanoke, Tar-Pamlico, Neuse, Cape Fear, and Brunswick rivers and the Albemarle Sound system. As of 1998, survey data indicated that spawning continued to occur in the Roanoke River/Albemarle Sound system and the Cape Fear River, and it is also thought to have occurred recently in the Neuse and Tar-Pamlico rivers. Some adult sturgeon apparently migrate upstream in the fall, although they may not spawn until the following spring. An examination by the NMFS interagency team of all databases in the state for entries for Atlantic sturgeon covering various years from 1957 to 1997 found a total of 1,210 Atlantic sturgeon recorded, and indicated that Atlantic sturgeon are present in all major rivers in North Carolina (NMFS/USFWS 1998).

South Carolina: Atlantic sturgeon were present historically in many South Carolina rivers and estuaries, although it is not known where spawning occurred. The 1998 NMFS/USFWS study concluded from sampling conducted within the previous two decades that Atlantic sturgeon were present in the following river systems: the Great PeeDee River, Waccamaw River, and Sampit River, all tributaries to Winyah Bay; the Santee River, Lake Moultrie, Cooper River, Ashley River, South Edisto River, Ashepoo River, and Combahee River, all tributaries to St. Helena Sound; the Broad/Coosawhatchie River; and the Savannah River. Based on the collection of juveniles, it was believed that spawning continued to occur in the Santee River, one or more of the Ashepoo, Combahee, or Edisto (ACE) Basin tributaries, the Savannah River, and possibly the Cooper, Great PeeDee, and Waccamaw rivers. All of the systems noted above, except for Lake Moultrie, probably provided nursery habitat (NMFS/USFWS 1998).

Georgia and Florida: The Altamaha River in Georgia is believed to support one of the most abundant Atlantic sturgeon populations in the Southeast, based on the presence of more than 2,000 juveniles found in a sample using trammel nets in the early 1990s. Of the juveniles sampled, 800 were believed to be age one fish. Another population of Atlantic sturgeon occurs in Georgia's Ogeechee River. Sampling efforts in the 1990s suggested that juveniles are scarce or absent in some years, indicating spawning or recruitment failure and a severely stressed population. Similarly, it is believed that a population of Atlantic sturgeon persists in the Satilla River in Georgia, but is under stress (NMFS/USFWS 1998). It has been hypothesized that nursery habitat in both the Ogeechee and Satilla rivers has been compromised during hot, dry summers by reduced dissolved oxygen levels from non-point source pollution and loss of thermal refugia from lowering the aquifer [Rogers et al. (1994), cited in NMFS/USFWS (1998)].

At the southern end of its range, recent sampling indicates that the Atlantic sturgeon has been extirpated from some rivers where it was historically reported. These include the St. Marys River in Georgia and Florida, where sampling has resulted in zero catch, and possibly Florida's St. Johns, St. Augustine, and St. Lucie rivers. However, it is unknown whether these rivers were ever used for spawning or merely by migrating populations. There is no evidence of current presence of Atlantic sturgeon in any of these systems (NMFS/USFWS 1998).

Ecology and Habitat

Adult Atlantic sturgeon are anadromous, primarily inhabiting marine and brackish waters, and ascending into fresh water for spawning only. Feeding migrations of up to 1,800 miles (3,000 kilometers) have been reported. The largest specimen ever recorded was 14 feet long and weighed 811 pounds (approximately 4.2 meters and 370 kg), but today the species rarely attains more than 6–7 feet and 130 pounds (approximately 2 meters and 60 kg) (ASMFC 2001a; Hochleithner and Gessner 1999). The maximum lifespan is reported to be 60 years (ASMFC 2001a; Hochleithner and Gessner 1999). Atlantic sturgeon are benthic (bottom) feeders; their food consists primarily of benthic invertebrates such as crustaceans, bivalves, and worms. Small bottom-dwelling fish may also be consumed, and seasonal preferences have been reported (Hochleithner and Gessner 1999; Friedland 2000; ASMFC 2001a).

Spawning season varies with water temperatures between April and July.

Spawning occurs at water temperatures between 55 and 72° F (13–22° C) over rocky or gravel substrate, with a preferable current velocity of 1.6–2.6 feet per second (0.5–0.8 meters per second). Spawning migration distances can be long, with reports of migrations of up to 900 miles (1,500 kilometers). Males reach spawning sites as much as 10 days prior to females (Hochleithner and Gessner 1999). Sexual maturity for Atlantic sturgeon varies widely depending on the climate at the point of distribution, with northern populations maturing much later than southern populations. For example, in the far northern extent of the species' range in the St. Lawrence River, females reach sexual maturity at 24–28 years and males at 20–24 years, while in the south females may reach maturity at 9–15 years and males at 7–9 years. Intervals between spawning also vary according to geographical distribution, from 1–4 years for males to 3–5 years for females (Hochleithner and Gessner 1999; Chapman 1999).

Egg size ranges from 2.3 to 2.8 millimeters in diameter, with fecundity varying from 16,000 to 24,000 eggs per kilogram of body weight (average = 20,000). Some references thus estimate that a female may carry 600,000–2,000,000 eggs (Hochleithner and Gessner 1999; Chapman 1999). Van Eenennaam et al. (1996), cited in Secor and Waldman (1999), estimated that fecundity ranged from 400,000 to 2,000,000. Hatching occurs at water temperatures between 61 and 66° F (16–19° C) after 120–140 hours. Juvenile sturgeon remain in freshwater for 1–3 years and then descend into estuaries. It may be six years from hatching before they migrate to the ocean (ASMFC 2001a). Adults descend the rivers immediately after spawning (Hochleithner and Gessner 1999).

Despite its highly migratory nature, the coastal movements of Atlantic sturgeon are believed to be largely, but not completely, confined to the biogeographic provinces in which their native rivers belong. The fidelity of Atlantic sturgeon to their native rivers is uncertain, and the genetic structure of populations of the species is still being learned. A 1996 study and 1997 analysis [Waldman et al. (1996) and Wirgin et al. (1997), both cited in NMFS/USFWS (1998)] of the stock structures of populations of Atlantic sturgeon showed three highly differentiated stocks: Canadian (St. Lawrence and Saint John rivers); Hudson River; and southeastern rivers (Edisto, Savannah, Ogeechee, Altahama, and Satilla). Furthermore, despite the geographic proximity of the southern rivers, mitochondrial DNA analysis in these studies indicated that stocks generally exchange less than one female per generation. A 1998 paper cited these low gene flows as evidence that natural recolonization of extinct or extirpated populations of Atlantic sturgeon will proceed slowly, complicating conservation and recovery efforts [Waldman and Wirgin (1998), cited in NMFS/USFWS (1998)].

More recent studies have supported the existence of the three basic regional divisions of Atlantic sturgeon populations identified in these studies. However, the addition of samples from more estuaries on the southeastern U.S. coast, larger sample sizes in southeastern rivers, and identification of far more haplotypes have allowed additional precision in distinguishing populations. The results of one study were consistent with the presence of a minimum of seven groupings of Atlantic sturgeon along the entire eastern seaboard. Within the southeast, the data indicated the presence of at least four genetically distinct stocks: those in the Albemarle Sound, the Cape Fear River, the Edisto River, and populations in the remaining three rivers (Savannah, Ogeechee, and Altamaha). Furthermore, although the genetic status of the three southernmost populations was not clear, there was some evidence of genetic uniqueness in these populations, despite their geographic proximity to one another (Wirgin et al. 2000).

Historic Fisheries/Catch Levels

Human fishing for Atlantic sturgeon dates back at least as far as 2190 B.C., when Native Americans used the species for food. In the United States, in the mid-nineteenth century Atlantic sturgeon were often caught in shad fishing operations and killed to protect fishing nets. At that time, Atlantic sturgeon roe was considered useful regionally only for fish bait and hog feed (Waldman 1999).

Major commercial fisheries in the United States developed later in the nineteenth century

as the potential value of sturgeon for caviar and meat became apparent. By 1860, fisheries existed in Delaware, Georgia, Maryland, New Jersey, New York, North Carolina, Pennsylvania, South Carolina, and Virginia, focusing on rivers where sturgeon aggregated to spawn (NMFS/USFWS 1998; Waldman 1999). Caviar fisheries focused on Atlantic sturgeon developed rapidly in the 1870s in the mid-Atlantic states, which was largely attributable to technology transfer from Europe on processing caviar and fishing techniques. Improved domestic and international transportation systems are believed to have been a contributing factor in the emergence of Atlantic sturgeon fisheries [Cobb (1900), cited in Secor and Waldman (1999)].

Delaware Bay supported the largest Atlantic sturgeon fishery in the United States during the peak years in the 1880s and 1890s, with fishermen operating from both New Jersey and Delaware. Kahnle et al. (1998), cited in ASMFC (1998b), reported that coastwide landings peaked in 1890 at an estimated level of 7,374,449 pounds (3,348,000 kg; 3,348 metric tons). Secor and Waldman (1999) placed the peak of the U.S. fishery slightly earlier, with the largest recorded catch of Atlantic sturgeon occurring in 1888, when U.S. landings totaled some 7.04 million pounds (3,502 tons; 3,152 metric tons). Of this latter estimate, Delaware Bay contributed 5.94 million pounds (2,970 tons; 2,655 metric tons), or 75 percent of the overall U.S. catch. Catch records suggest a "fishing up" period in the Bay during the 1880s followed by a brief period of peak catch levels. In 1890 sturgeon ranked second in tonnage (590 metric tons) for Delaware's state fisheries, exceeded only by American shad at 680 metric tons (Secor and Waldman 1999).

Few if any regulations existed to control catch during this initial period of heavy exploitation, and many fisheries quickly began to collapse. Catch data from the Delaware River and Bay showed that catch declined to less than half of its peak by 1897 (Waldman 1999). In that year, the fishery had close to 1,000 fishermen dispersed among fishing camps located on scows or house boats that served as sleeping quarters and caviar processing plants, allowing caviar to be processed rapidly. Cobb (1900, cited in Secor and Waldman 1999) reported that two-thirds of the fish yielded marketable caviar, or "hard roe," and males comprised only 10% of the catch. Flesh was smoked and marketed domestically, mostly in New York City.

By 1901, Delaware and New Jersey landings dropped to six percent of peak levels. However, as the fishery developed, the monetary value of the overall catches remained relatively constant, as price varied inversely with supply. Fishermen received $9 to $12 per keg of caviar in 1885, about $40 per keg in 1894, and as much as $105 per keg in 1899. Most of the caviar was shipped through New York City to Germany in one-quarter to two-pound cans. The only attempt at regulation during this time came in New Jersey, which in 1891 forbade the keeping of individual sturgeon less than three feet long (Secor and Waldman 1999; Waldman 1999).

The crash at the end of the nineteenth century largely ended directed fishing for Atlantic sturgeon in the Delaware River and Bay. The "clear-cutting" of female stocks had led to an apparent recruitment failure in this once productive sturgeon fishery, likely leaving little to exploit. A review of records of Atlantic sturgeon captured in the Delaware River estuary from 1958 through 1980, for example, showed the capture of only 130 Atlantic sturgeon over this 23-year period, including incidental catches [Brundage and Meadows (1982), cited in Secor and Waldman (1999)].

Similar cycles occurred in other fisheries. For example, in the Chesapeake Bay, Maryland landings peaked at 141,000 pounds (~64,090 kg; 64 metric tons) in 1897, but fell to 8,415 pounds (~3,825 kg; 3.8 metric tons) by 1901. Virginia's catch remained strong from 1890 to 1897, ranging from 584,000 to 814,000 pounds (265,455–370,000 kg; 265.5–370 metric tons), but fell to 171,000 pounds (~76,950 kg; 77 metric tons) by 1901. In 1920, combined landings in Maryland and Virginia totaled 23,000 pounds (~10,455 kg; 10.45 metric tons) (Waldman 1999).

It should be noted that some of these data could be overestimates, as catch records for the Atlantic Ocean at the time likely did not separate catch of Atlantic sturgeon from that of shortnose sturgeon (Friedland 2000). However, Secor and Waldman (1999) note that although shortnose sturgeon likely occurred

throughout much of the fishing grounds, that species' much smaller size (rarely more than 44 pounds [20 kg]) makes it unlikely that shortnose sturgeon would be taken in the 13-inch mesh gill nets typical of the time. Waldman and Secor thus assumed that only Atlantic sturgeon were included in the historical catch records they reviewed for the Delaware River and Bay.

Following the collapse of catch levels in the Delaware River and Bay and other fisheries such as the Chesapeake Bay, the focus of the Atlantic sturgeon fishery shifted to various other river systems during the twentieth century. During the 1970s and 1980s, South Carolina, North Carolina, and Georgia accounted for nearly 80% of total U.S. landings, leading to a predictable decline in stocks. By 1990, six jurisdictions prohibited sturgeon catch: Pennsylvania, the District of Columbia, the Potomac River Fisheries Commission, Virginia, South Carolina, and Florida. By 1996, closures had been instituted in Maine, New Hampshire, Massachusetts, Pennsylvania, the District of Columbia, the Potomac River, Virginia, North Carolina, South Carolina, and Florida. Rhode Island, Connecticut, Delaware, Maryland, and Georgia adopted a seven foot (2.13 meter) minimum total length size, designed to allow females an opportunity to spawn once before being caught (NMFS/USFWS 1998).

New York and New Jersey's Hudson River population of Atlantic sturgeon formed the basis of the last viable commercial fishery. Landings averaged about 33,000 pounds (15,000 kg; 15 metric tons) per year in the early 1980s. A rapid increase in sturgeon catch in the Hudson, to a peak of 266,200 pounds (121,000 kg; 121 metric tons) in the early 1990s as caviar reached $100 per pound for fishermen, led to evidence of an impending population crash. The New York fishery was subsequently closed (ASMFC 1998b; NMFS/USFWS 1998; Waldman 1999). Table 3.1.1 shows available information on U.S. landings of Atlantic sturgeon in the latter years of legal commercial fishing from 1962 to 1997.

The history of U.S. Atlantic sturgeon fisheries thus suggests a cycle of "boom and bust" that moved from river system to river system, depleting each in turn. The tremendous catch levels of the early years of the fishery did not represent a sustainable industry, but rather rapid overexploitation. Compared to the estimated 7 million pounds or more taken annually when the Delaware Bay fishery was at its peak in the late nineteenth century (which, as noted, may have included shortnose as well as Atlantic sturgeon), the combined total for all U.S. eastern seaboard states for the 36 years from 1962 to 1997 was slightly over 4.4 million pounds (approximately 2 million kg; 2,000 metric tons), and the latter level prompted concerns about the sustainability of depleted populations (NMFS/USFWS 1998; Friedland 2000; ASMFC 2001a).

In 1998 ASMFC recommended, and all eastern seaboard jurisdictions imposed, a complete moratorium on catch and possession of Atlantic sturgeon. The history and details of these actions are outlined in Section IV.

In Canada, Atlantic sturgeon fisheries were never based on caviar harvest, as the supply was too irregular to support a caviar industry. Even so, Atlantic sturgeon landings declined in Canada during periods of the twentieth century as they did in the United States (NMFS/USFWS 1998). Statistics on historic catch levels in the largest Canadian fishery—the upper estuary of the St. Lawrence River—indicate that annual landings ranged between 20 and 40 metric tons between 1940 and 1966. Between 1967 and 1975, however, landings dropped to almost nothing, as sturgeon became all but absent from the fishery. The exact cause of the disappearance of Atlantic sturgeon during this period has not been demonstrated with certainty, and remains a source of concern. It has been speculated that river dredging, deposition of dredging material in spawning grounds, chemical pollution (especially the widespread use of pesticides), overfishing, or a combination of these factors may have been responsible. Catch of the species later rebounded, reaching more than 100 metric tons in 1988 and 120 metric tons in 1993, corresponding with an increase in market demand for Atlantic sturgeon (Caron and Tremblay 1999).

Two Atlantic sturgeon fisheries remain in Canada, the major one in Quebec's St. Lawrence River and a minor one in New Brunswick's Saint John River (Caron and

Table 3.1.1 NMFS-Reported U.S. Atlantic Sturgeon Live Weight Landings (in kg) by State, 1962–1997*

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	SC	GA	FL	TOTAL
1962	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22,226	17,962	816	181	41,186
1963	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A N	/A	N/A	19,641	23,859	1,225	0	44,724
1964	33	0	1,855	543	0	0	0	0	0	0	15,331	29,121	862	0	47,745
1965	271	0	1,488	854	0	0	0	0	0	0	34,881	22,498	1,225	0	61,217
1966	201	0	850	2,022	0	0	0	0	0	0	26,717	19,414	590	0	49,794
1967	718	0	1,070	1,190	0	0	0	0	0	0	17,463	15,059	318	0	35,819
1968	258	0	1,243	299	0	0	0	0	0	0	21,273	20,049	227	0	43,348
1969	1,262	0	765	1,212	0	0	0	0	0	0	59,920	18,280	499	0	81,937
1970	2,813	0	647	1,332	0	0	0	0	0	0	54,386	2,858	1,633	0	63,668
1971	388	0	825	2,037	0	0	0	0	0	0	35,516	34,836	1,724	0	75,326
1972	479	0	1,276	969	0	0	0	0	0	0	69,903	30,853	3,498	0	106,977
1973	144	0	833	525	0	0	0	0	0	0	25,334	20,124	1,155	45	48,161
1974	167	0	1,168	1,261	0	0	0	0	0	0			858	0	67,099
1975	646	0	765	459			0		0	0			917	0	53,418
1976	607	0	389	551	0	0	0	0	0	0	20,770	40,010	630	0	62,956
1977	2,086	0	1,432	265	0	0	0	0	0	0	13,477	52,037	1,310	105	70,711
1978	844	0	1,884	163	0	0	7,362	0	0	0	14,459	42,722	4,926	11	72,372
1979	1,436	0	599	242			6,943	0	0	0			1,471	95	65,472
1980	1,559	0	1,064	511			5,634		0	0			6,451	76	88,241
1981	1,499	95	1,119	277	0	0	5,167	0	0	0	14,280	41,718	10,183	121	74,459
1982	1,247	0	1,103	490	0	0	3,386	0	436	1,681	10,599	45,429	12,756	68	77,195
1983	1,042	112	1,453	743	0	0	7,829	0	1,255	933	8,154	8,450	4,561	78	34,610
1984	841	21	2,358	2,939	0	0	13,844	0	1,740	1,898	20,389	11,737	3,307	0	59,073
1985	645	16	3,212	4,287	0	0	8,835	0	1,018	618	12,222	7,002	8,465	0	46,321
1986	729	26	2,981	3,399	0	15,537	9,175	0	1,643	0	9,325	0	4,036	0	46,852
1987	412	345	3,068	1,926	0	13,856	9,100	0	500	0	6,154	0	3,568	0	38,930
1988	213	536	3,025	2,333	0	25,944	5,911	0	1,083	0	3,563	0	3,345	0	45,953
1989	344	54	248	1,169	771	8,581	38,615	0	1,184	0	3,048	0	2,619	0	56,632
1990	116	64	255	1,003	728	21,919	58,240	0	1,566	0	3,065	0	1,876	0	88,832
1991	25	0	482	1,358	1,252	37,807	53,189	0	1,828	0	1,667	0	726	0	98,334
1992	0	0	52	1,197			38,138		614	0	0	0	981	0	58,766
1993	29	0	218	457	0	10,390	16,243		1,920	0	0	0	604	0	31,386
1994	0	0	27	62			23,300		343	0	0	0	78	0	43,458
1995	0	0	201	263	317		5,795		94	0	0	0	446	0	17,351
1996	0	0	0	171	95	11	2,421	0	206	0	0	0	106	0	3,010
1997	0	0	0	24	0	284	0	0	75	0	0	0	0	0	382
Totals:	**21,056**	**1,269**	**37,955**	**36,533**	**319,127**	**181,995**	**319,127**	**1,524**	**15,505**	**5,130**	**638,533**	**651,153**	**87,992**	**780**	**2,001,715**

* Source: NMFS/USFWS (1998).

Key: N/A = Not available; ME = Maine; NH = New Hampshire; MA = Massachusetts; RI = Rhode Island; CT = Connecticut; NY = New York; NJ = New Jersey; DE = Delaware; MD = Maryland; VA = Virginia; NC = North Carolina; SC = South Carolina; GA = Georgia; FL = Florida

Tremblay 1999; Anon. 2001a). Current Canadian catch and trade levels are discussed in more detail later in this report in Section IV on Management and Regulation and in Section V on Legal and Illegal Trade.

Conservation Status and Challenges/Threats

IUCN listed the Atlantic sturgeon as at Lower Risk (near threatened) in its 2000 Red List, and designated the species as close to being Vulnerable (Haywood 1999; IUCN 2001). The IUCN/SSC Sturgeon Specialist Group is in the process of reassessing the status of North American sturgeon and paddlefish species and stocks for inclusion in an upcoming 2003 Red List of Threatened Species. As it currently stands, the proposed listing for the Atlantic sturgeon is Near Threatened (R. St. Pierre, IUCN/SSC Sturgeon Specialist Group, *in litt.* to IUCN/SSC Wildlife Trade Programme, September 28, 2001).

The Atlantic sturgeon was first listed under CITES in 1975, when the species was placed in Appendix I. Canada, however, took a reservation to the listing. In 1979, the species was transferred to Appendix II, and Canada withdrew its reservation. The Atlantic sturgeon remains in Appendix II today. The EU listed the species in its Annex B in June 1997 (CITES 2001a).

In the United States, in 1988 NMFS announced the creation of a list of candidate species being considered by the Secretary of the Department of Commerce for listing as threatened or endangered species, but not yet the subject of a proposed rule. NMFS added the Atlantic sturgeon to this list in 1991, and it remained on the revised list published in 1997 (NMFS/USFWS 1998). In late 1998, the U.S. Department of Commerce decided that listing as threatened or endangered under the ESA was not warranted at that time (Field et al. 1999). In Canada, Atlantic sturgeon are protected and managed under the Federal Fisheries Act (Anon., 2001a). The species has not been designated as endangered, threatened or of special concern by COSEWIC.

Potential challenges or threats to Atlantic sturgeon populations are briefly discussed below.

Historic overfishing/bycatch. There is little doubt that past commercial catch was a significant cause of the decline of Atlantic sturgeon stocks from historical times to present. Papers dating back as far as 1888 expressed concern about the unsustainable exploitation of the species. Whereas Atlantic sturgeon were once apparently abundant in river systems throughout much of the species' range, the cycle of "boom-and-bust" commercial fisheries described above is generally believed to have contributed to its severe depletion (NMFS/USFWS 1998; Waldman 1999).

While directed catch of Atlantic sturgeon is currently banned in the United States and restricted in Canada, bycatch continues to occur in commercial fisheries along the entire Atlantic coast. U.S. fisheries in which Atlantic sturgeon have been captured include the American shad (gill nets), Atlantic cod (gill nets, incidental hook and line), bluefish (gill nets, trawl), groundfish (trawl), horseshoe crab (trawl), monkfish (gill nets), river herring (gill nets), southern shrimp (trawls), spiny dogfish (gill nets), striped bass (gill nets, pound nets), summer flounder (trawl, perhaps gill nets in North Carolina), weakfish (gill nets), and northeastern and southeastern whelk (trawls). Limited bycatch of juvenile Atlantic sturgeon has also been documented in lobster, crab, and fish pots (ASMFC 1998b).

NMFS/USFWS (1998) examined threats to the Atlantic sturgeon from bycatch in other commercial fisheries, recreational fishing, and mortality associated with scientific research. It found that the types of bycatch reported in ASMFC (1998b) were reported in rivers, estuaries, the near-shore ocean, and the Exclusive Economic Zone (EEZ). Although such bycatch can pose a threat to the species if the sturgeon are injured or killed while being caught, data on mortality from the Delaware and Hudson rivers did not indicate that bycatch was a significant threat to species survival; it could, however, impede recovery. The NMFS/USFWS survey determined that more data are needed to assess the impact of bycatch in other river populations. Because any level of bycatch is likely to delay recovery of the Atlantic sturgeon, there is a clear need to better document its extent, rate of mortality in various

fishing gears, and population level impact (ASMFC 1998b; NMFS/USFWS 1998).

To eliminate the incentive to keep Atlantic sturgeon obtained as bycatch, all U.S states in the species' range currently prohibit even possession of fish taken from the wild (NMFS/USFWS 1998). Canada similarly prohibits retention of Atlantic sturgeon caught as bycatch in gear not targeting the species (Anon. 2001a). There is no evidence that recreational fishing or mortality associated with scientific research poses a threat to Atlantic sturgeon, although the NMFS/USFWS study recommended that gill nets be used sparingly to capture Atlantic sturgeon for research purposes (NMFS/USFWS 1998).

Habitat degradation/restricted range. Over the last century and more, dams for hydroelectric power generation and flood control have altered rivers and habitat important to Atlantic sturgeon in both the United States and Canada. Dams can affect anadromous species like the Atlantic sturgeon in numerous ways. Perhaps their greatest impact to Atlantic sturgeon is the denial of access to upstream spawning habitat, because the species is not known to use fish passageways successfully. Dam intake structures can also entrain migrating sturgeon (NMFS/USFWS 1998). Suitability of riverine habitat for spawning, which depends on annual fluctuations in water flow, can be greatly reduced by the alteration of free-flowing rivers to reservoirs, as well as changes in downstream flows and water temperatures that are important cues leading to spawning behavior. Along with dams, hydroelectric power plants have numerous potential impacts, including altered dissolved oxygen concentrations and temperature, artificial destratification, water withdrawal, changes in sediment load and channel morphology, accelerated eutrophication and changes in nutrient cycling, and contamination of water and sediment [Hill (1996), cited in NMFS/USFWS (1998)].

While it is not possible to assess the impact of dam construction on Atlantic sturgeon in rivers where historic spawning areas are unknown, the 1998 NMFS/USFWS survey found that of the 25 U.S. rivers for which habitat accessibility could be quantified, only three (the Merrimack, Housatonic, and Susquehanna rivers) suffered a loss of 30% or more of that habitat to dams. The survey calculated that dams blocked access to 10–30% of habitat on the Kennebec, Penobscot, and Salmon Falls rivers, and less than 10% on the Androscoggin, Sheepscot, Oyster, Connecticut, Hudson, Delaware, Potomac, Rappahannock, York, James, Neuse, Ashepoo, Combahee, Edisto, Savannah, Ogeechee, Altamaha, Satilla, and St. Marys rivers. A substantial portion of sturgeon habitat in the Santee River was also blocked by the Wilson Dam, although the precise amount had not been quantified at the time of the survey (NMFS/USFWS 1998). Based on this information, the NMFS/USFWS survey concluded that overall, little U.S. Atlantic sturgeon habitat has been lost to dams.

In Canada, no dams that would impede migration of Atlantic sturgeon have been constructed in their St. Lawrence River range. In New Brunswick's Saint John River, construction of the Mactaquac Dam in 1967 likely prevented migrating sturgeon from reaching possible spawning grounds upriver. However, there is little substantive information to demonstrate a negative impact on this population, perhaps because of the presence of spawning grounds downstream from the dam. Whether the regulation of river flow by the dam has adversely affected these spawning grounds remains unknown (Anon. 2001a).

Dredging of riverine, near-shore, and offshore areas for commercial shipping, recreational boating, construction, and marine mining can also harm Atlantic sturgeon directly or indirectly. Direct impacts include fish being lethally sucked into dredging machines or, probably less commonly, colliding with propellers from increased boating activity. Indirect but equally significant impacts of dredging on aquatic ecosystems and species include removal or burial of organisms, turbidity/siltation effects, contaminant release and uptake, noise/disturbance, alterations to the hydrodynamic regime, disruption of spawning migrations, increased sedimentation in spawning areas, and loss of riparian habitat [Chytalo (1996), cited in NMFS/USFWS (1998)]. Dredging activities can also disturb or eliminate benthic feeding areas upon which Atlantic sturgeon depend, and may eliminate deep holes or alter rock substrates that are important habitat features for the species

[Smith and Clugston (1997), cited in NMFS/USFWS (1998)].

Information from Canada indicated that extensive dredging and modification of the riverbed in the St. Lawrence River over the past few decades to accommodate commercial vessel traffic is believed to have contributed to a major decline in Atlantic sturgeon abundance in the 1960s and 1970s, largely because of increased sedimentation (Anon. 2001a). In the United States, dredging occurs on a regular basis in some river systems utilized by Atlantic sturgeon, such as the Connecticut River. The spawning population of Atlantic sturgeon in the Connecticut River is presumed extirpated; it is not clear whether dredging was a contributing factor to the extirpation, or whether the regular dredging may impede efforts to re-establish the species (NMFS/USFWS 1998). Overall, however, the NMFS/USFWS survey found that little or no dredging occurred in many U.S. river systems used by Atlantic sturgeon in the recent years leading up to 1998. In others authorities made efforts to minimize the impact on migrating sturgeon and other species (NMFS/USFWS 1998; NMFS/National Oceanic and Atmospheric Administration [NOAA] 2001a).

Pollution/water quality. Industrial activities, forestry and agricultural practices, coastal development and urbanization, and other human activities can affect the quality of water in riparian and river systems directly and indirectly, and in both near-shore and offshore areas. Industrial activities can discharge pollutants, change water temperature and levels of dissolved oxygen, and add excess nutrients. Forestry and agricultural practices often produce erosion, and can also introduce fertilizers, herbicides, insecticides and other chemicals into water systems through run-off, and thereby promote nutrient enrichment and alteration of water flow (NMFS/USFWS 1998; Anon. 2001a). Coastal development and urbanization can result in increased storm-water discharges, non-point source pollution, and rapid erosion (NMFS/USFWS 1998).

Atlantic sturgeon may be particularly vulnerable to such contamination because they are benthic feeders and their long lifespan allows for bio-accumulation of heavy metals and organochlorine compounds in their fatty tissue. Scientific studies have indicated that toxic metals, polycyclic aromatic hydrocarbons (PAH), pesticides, and polychlorinated biphenyls (PCBs) can produce acute lesions, retard growth, and impair reproduction in aquatic life (NMFS/USFWS 1998). Unfortunately, few studies have been conducted specifically on the effects of such pollutants on Atlantic sturgeon, although one 1995 study suggested that certain deformities and ulcerations found in Atlantic sturgeon in North Carolina's Brunswick River might be due at least in part to poor water quality [Moser and Ross (1995), cited in NMFS/USFWS (1998)]. Studies of contaminants in shortnose sturgeon in South Carolina found dioxin and furans at levels that can adversely affect the development of sturgeon fry [J. Iliff, NOAA, unpublished data, cited in NMFS/USFWS (1998)].

Life history characteristics/limitations. As an anadromous species, Atlantic sturgeon face a number of conservation challenges because they use rivers, estuaries, bays, and the ocean at various times in their lifespans. This reliance on the health of multiple habitats, plus the species' long lifespan and late age at maturation, leave Atlantic sturgeon vulnerable to both habitat pressures and overfishing (NMFS/USFWS, 1998). The relative importance of various threats has shifted over time, and also varies from population to population and from river system to river system.

Non-indigenous disease or competition. Concern that non-indigenous sturgeon pathogens could be introduced, most likely through aquaculture operations, has led ASMFC to impose restrictions on the importation, captive propagation, and commercial aquaculture of Atlantic sturgeon (ASMFC 1996, 2001b). This concern, and resultant limitations, terms, and enforcement and reporting requirements on these activities, are described in more detail in Section VI of this report on Hatcheries and Commercial Aquaculture. There is also some concern that the aquarium industry could possibly be a source for transfer of non-indigenous pathogens or competitive non-indigenous species from one geographic area to another, primarily through the release of aquaria fish into public waters (NMFS/USFWS 1998).

3.2 Gulf Sturgeon *(Acipenser oxyrinchus desotoi)*

Illustration by Paul Vecsei

The Gulf sturgeon, also known as the Gulf of Mexico sturgeon, is endemic to the United States. There is a general consensus that the disjunct distributions, differences in relative spleen length, distinct life history characteristics, and fixed differences in the control region of mitochondrial DNA between the Gulf sturgeon (*A. o. desotoi*) and the Atlantic sturgeon (*A. o. oxyrinchus*) justify their designation as separate subspecies (Ong et al. 1996; Stabile et al. 1996). The United States designated the Gulf sturgeon as a threatened species under the ESA in 1991. While some details of its historic range, current distribution, and historic catch are sketchy, certain basic information has been documented.

Historic Range and Current Distribution

Wooley and Crateau (1985) reported that Gulf sturgeon occurred historically in most major river systems from the Mississippi River to the Suwannee River, Florida, and in marine waters of the central and eastern Gulf of Mexico south to Florida Bay. The species is believed to be reduced from historic levels, but population estimates are not available throughout its range. Figure 2 shows the historic distribution of Gulf sturgeon.

Louisiana: Along with very occasional captures offshore, Gulf sturgeon have been recorded in the Mermantau River Basin and in the Mississippi River and its Basin. One report from 1936 included a sturgeon weighing 503 pounds (228.6 kg) and measuring 111 inches (282 centimeters) landed at the mouth of the Mississippi River [Reynolds (1993), cited in U.S. Fish and Wildlife Service and Gulf States Marine Fisheries Commission [USFWS/GSMFC] (1995)]. In the Lake Pontchartrain Basin, Gulf sturgeon have been routinely collected by Louisiana state researchers and commercial and recreational fishermen in Lake Pontchartrain, Lake Borgne, and the Rigolets. For example, sturgeon measuring up to 86.6 inches (220 centimeters) and weighing up to 258 pounds (117.3 kg) were incidentally caught by shrimp trawlers, netters, and recreational fisheries in Lake Pontchartrain from 1989 to 1993. Incidental catches of Gulf sturgeon have also been reported in the Tchefuncte, Tickfaw, Tangipahoa, Amite, Pearl, Middle Pearl, Bogue Chitto, and East Pearl rivers. Incidental catches and Gulf sturgeon collected in research studies have been similarly reported in the Mississippi Sound, as well as at least one incidentally taken fish in Biloxi Bay (USFWS/GSMFC 1995).

Mississippi: Gulf sturgeon have been recorded in both Pascagoula Bay and the Pascagoula River, both of which are in the Pascagoula River Basin. Also within this basin, Gulf sturgeon have been reported in the Chickasawhay, Leaf, and West Pascagoula rivers, which are tributaries of the Pascagoula River (USFWS/GSMFC 1995).

Alabama: Gulf sturgeon are also reported to be present in the Mobile River Basin in Alabama, which includes Mobile Bay, the Mobile River, and tributaries such as the Tensaw, Blakely, Tombigbee, and Alabama rivers. Many of the fish reported were incidental catches netted and released by commercial fishermen. Incidental catches of Gulf sturgeon are believed to occur annually in the Tombigbee River in the remaining riverine

Figure 2 Historic Gulf Sturgeon Range

habitat below Coffeeville Dam, and in the Alabama River in remaining habitat below Claiborne Dam (USFWS/GSMFC 1995).

Florida: Gulf sturgeon have been recorded in recent decades in the Pensacola Bay system, which includes five interconnected estuarine bays (Pensacola, Escambia, Blackwater, East, and Little Sabina, as well as the Santa Rosa Sound). A Gulf sturgeon was collected in Pensacola Bay in 1978. The species has since been recorded in the Bay in 1994 and 2000, when researchers collected and tagged six Gulf sturgeon. Gulf sturgeon are also known to migrate into Escambia Bay in the fall and winter, and may use the other estuaries in this overall system, although information documenting their possible distribution had not been collected as of 2001 (USFWS/GSMFC 1995; Wakeford 2001).

In addition to estuarine habitat, three primary rivers flow into the Pensacola Bay system: the Escambia, Yellow, and Blackwater Rivers. Prior to 1980, recreational anglers in the Escambia River reported that sightings of Gulf

sturgeon were fairly common. That is no longer the case, although incidental catches or captures by researchers were reported in 1995, 1998, and 2000, and sightings have been reported on the Conecuh River, a tributary of the Escambia. Landings of Gulf sturgeon were occasionally reported in the Yellow River prior to a 1984 moratorium on sturgeon fishing. More recently, Gulf sturgeon captures for research, tagging, and release were conducted by federal and state authorities or universities in 1993, 1997, 1998, 1999, and 2000. Three Gulf sturgeon were collected in the Blackwater River in 1991 (USFWS/GSMFC 1995; Wakeford 2001).

Gulf sturgeon have similarly been collected by federal, state, and university researchers in Florida's Choctawhatchee Bay Basin. In Choctawhatchee Bay itself, collections have included one dead specimen found on a beach in the Santa Rosa Sound in 1988, 50 Gulf sturgeon collected in the eastern part of the Bay off the mouths of the Indian, Cyprus, and Choctawhatchee rivers in 1992, four sturgeon collected in Jolly Bay in 1993, 52 sturgeon collected off the south shore of the Bay in 1996, and a dead specimen found near Destin in 1999. It is believed that the Bay provides an important habitat for Gulf sturgeon overwintering (USFWS/GSMFC 1995; Wakeford 2001).

By far the greatest number of Gulf sturgeon in the Choctawhatchee Bay Basin system have been found in the Choctawhatchee River. During tag and release studies conducted during the first half of the 1990s, annual sightings were reported from the river below its confluence with the Pea River in south-central Alabama, as well as in the Pea River tributary itself (USFWS/GSMFC 1995). More recently, 450 gulf sturgeon were gill-netted, tagged, and released during a 16-day period in the fall of 1999, leading to a USFWS population estimate of approximately 3,000 fish for the Choctawhatchee River (Wakeford 2001). An estimate published in 2000 for Gulf sturgeon older than age 2 in the river indicated a range of 1,700 to 3,000 fish [Lorio (2000), cited in R. St. Pierre, IUCN/SSC Sturgeon Specialist Group, *in litt*. to IUCN/SSC Wildlife Trade Programme, September 28, 2001].

St. Andrews Bay and Ecofina Creek (which provides the Bay's largest inflow) may have provided important Gulf sturgeon habitat in the past. Ecofina Creek is considered one of Florida's most pristine waterways, and Gulf sturgeon were collected by biologists in the creek in 1961; however, no reports of the species' presence have been documented since the construction of a dam in 1962. Sparse reports of Gulf sturgeon have been recorded or sighted in St. Andrews Bay as recently as 1999, and the St. Andrews Bay system may continue to provide winter feeding habitat for the species (Wakeford 2001).

The Gulf sturgeon population in Florida's Apalachicola River (part of the larger Apalachicola-Chattahootchee-Flint river system and the Apalachicola Bay system) once supported the state's largest and economically most important sturgeon fishery. Prior to completion of the Jim Woodruff Lock and Dam (JWLD) in 1957, there had been reports of Gulf sturgeon in this system as far north as the Flint River in Georgia. USFWS has monitored the Apalachicola River's sturgeon population since 1979, and collected and tagged more than 500 Gulf sturgeon below JWLD during 1979 to 1999 (Wakeford 2001). From 1984 to 1993, the estimated annual number of adult fish below the dam ranged from 96 to 131, with a mean of 115 (USFWS/GSMFC 1995). Based on more recent collection and tagging activities, the population was estimated to be 270 in 1998 and 321 in 1999 (Wakeford 2001). Gulf sturgeon are also believed to inhabit the Brothers River, a tributary of the Apalachicola River, before migrating to the base of JWLD to spawn. Gulf sturgeon have also been caught by commercial gill net fishermen and shrimp trawlers in Apalachicola Bay (USFWS/GSMFC 1995; Wakeford 2001). Elsewhere in the Florida panhandle, Gulf sturgeon have been recorded in the Ochlockonee River, which is part of the Ochlockonee River Basin (USFWS/GSMFC 1995; Wakeford 2001).

Farther east and south, the Suwannee River Basin is believed to support the largest and most viable Gulf sturgeon population in Florida. Mark and release efforts by the Caribbean Conservation Corporation from 1986

to 1995 produced 1,670 spring-migrating Gulf sturgeon at the mouth of the Suwannee River. USFWS/GSMFC (1995) estimated that the annual population size ranged between 2,250 and 3,300 fish, with an average weight of approximately 40 pounds (18 kg). More recent population estimates of Gulf sturgeon older than age two in the Suwannee River have ranged from 3,152 to 7,650 [Chapman et al. 1997; Sulak and Clugston (1999), cited in R. St. Pierre, IUCN/SSC Sturgeon Specialist Group, *in litt*. to IUCN/SSC Wildlife Trade Programme, September 28, 2001; Wakeford (2001)]. Wakeford (2001) speculated that the ultimate survival of a sustainable Gulf sturgeon population in Florida may depend on successful reproduction in the Suwannee River, because it is the only major unimpounded, undiverted, and relatively unpolluted river along the northwestern coast of the Gulf of Mexico.

South of the Suwannee River system, contemporary accounts of Gulf sturgeon are rare. Prior to 2002, Tampa Bay (which, as discussed below, once had a significant Gulf sturgeon fishery), was the site of Gulf sturgeon captures in 1987 and 1992. In March 2002, a gravid female Gulf sturgeon estimated at 40 years of age or older washed up dead in Tampa Bay, prompting discussion of whether it was in the area to spawn or was a stray from another system such as the Suwannee River (St. Petersburg Times 2002). Charlotte Harbor Basin has also produced recorded specimens of both juvenile and adult fish, and is believed to represent the southern terminus of the species' range (USFWS/GSMFC 1995; Wakeford 2001).

Ecology and Habitat

Like Atlantic sturgeon, Gulf sturgeon are anadromous. However, unlike Atlantic sturgeon, which spend much of their lives in marine and near-shore waters, adult and sub-adult Gulf sturgeon are believed to spend eight to nine months each year in rivers and three to four months in estuaries or the Gulf of Mexico, usually during winter. Juvenile Gulf sturgeon under two years old are believed to remain in riverine habitats and estuaries year-round (USFWS 1994a; USFWS/GSMFC 1995).

Based on historical examples, Gulf sturgeon are believed to be able to grow to a length of up to eight or nine feet (2.4–2.7 meters) and a weight of up to 450–500 pounds (approximately 200–225 kg) (USFWS/GSMFC 1995). Chapman (1999) estimated their maximum weight at 440 pounds (200 kg). Fish captured in studies in recent decades have tended to be smaller. For example, one study from the Apalachicola River estimated the age of 76 sturgeon from 1982 to 1990, and found fish from 2 to 28 years old with lengths ranging from 18.5 to 89.4 inches (47 to 227 centimeters) and weights ranging from 0.4 to 200 pounds (0.2 to 90.7 kg) (USFWS/GSMFC 1995). Chapman (1999) estimated the maximum longevity of Gulf sturgeon at 42 years.

Studies of Gulf sturgeon migration in various rivers indicate that sub-adult and adult fish generally begin to migrate into rivers from the Gulf when water temperatures are 15 to 20° C (59 to 68° F). At this time, from mid-February through April, some adults are sexually mature and in ripe condition. Many Gulf sturgeon are believed to spend summer months near the mouths of springs and in cool-water habitat; sturgeon are often found congregated near deep water holes or in areas of deeper water with sand and gravel substrates. Because of the paucity of historical biological data, it is impossible to determine if these areas represent preferred historic habitat or are the only habitat remaining following the damming of rivers. They remain in the river systems until late fall; most return to estuaries or the Gulf of Mexico by mid-November or early December when surface water temperatures are 18 to 23° C (about 64 to 74° F) (USFWS/GSMFC 1995; Wakeford 2001).

Although many details regarding the timing, location, and habitat requirements for spawning among Gulf sturgeon populations remain not well known or documented, sites in the Suwannee River where sturgeon eggs have been collected are characterized by river banks composed of limestone bluffs and outcroppings, and the river bottom consists of cobble, limestone, gravel, and sand (Wakeford 2001). A substrate of exposed bedrock overlain with gravel and small cobble used by spawning Gulf sturgeon has been called a "sturgeon spawning reef" [Sulak and Clugston (1999), cited in Wakeford (2001)]. Bedrock and clean gravel substrate also appear to be critical to Gulf sturgeon in their early-life-

history stages because they offer eggs a surface to adhere to and shelter for developing larvae [Sulak and Clugston (1998), cited in Wakeford (2001)]. The water depth ranges from 1.4 to 7.9 meters, and water temperature ranges from 18.3 to 22° C [Marchant and Shutters (1996); Sulak and Clugston (1999), both cited in Wakeford (2001)]. A study by Huff [1975, cited in USFWS/GSMFC (1995)] in the Suwannee River found that sexually mature females ranged from 8 to 17 years old. Chapman (1999) estimated the age at maturity at 7–12 years. Fecundity is estimated at 9,000 to 21,000 per kilogram of female body weight, and spawning is believed to take place for both males and females at intervals of from one to three years. Egg size is estimated at 2.3 to 2.8 millimeters, with eggs varying in color from gray to brown to black (USFWS/GSMFC 1995; Chapman 1999).

Analysis of mitochondrial DNA has indicated that there are significant differences among sturgeon stocks in various river systems. Stabile et al. (1996) identified a minimum of four regional or river-specific populations: (1) Pearl River, Lousiana and Pascagoula River, Mississippi; (2) Escambia and Yellow rivers, Florida; (3) Choctawhatchee River, Florida; and (4) Apalachicola, Ochlockonee, and Suwannee rivers, Florida. There is also an apparent break between Apalachicola/ Suwannee River populations and populations to the west of the Apalachicola River. These data suggest that Gulf sturgeon likely exhibit river-specific fidelity and strong maternal homing fidelity, as there are no obvious biogeographic barriers in the Gulf of Mexico, and these seasonally migratory fish have the opportunity to move between relatively proximate river systems. However, there is incomplete knowledge about the homing fidelity of any sturgeon species (USFWS/GSMFC 1995; Stabile et al. 1996). As with the Atlantic sturgeon, this characteristic could have implications for natural re-population of river systems in which the species is extirpated.

Food is believed to include crabs, amphipods, isopods, midge larvae, mud shrimp, and plant material. Sub-adult and adult fish apparently do not feed in freshwater riverine habitats. Why Gulf sturgeon feed for three to four months, and then do not feed for the following eight or nine months, is unclear (USFWS/GSMFC 1995).

Historic Fisheries/Catch Levels

Like other sturgeon species, Gulf sturgeon were once fished heavily for caviar, meat for smoking, and isinglass, a gelatin from the swim bladder used in jellies, wine and beer clarification, special cements, and glues (USFWS/GSMFC 1995). While there are sporadic data from some commercial river fisheries, it is difficult to assemble an overall picture of the level of historic catch throughout the species' range.

Available data suggest that historic catch was concentrated in Florida, where from 1886 to 1901 Gulf sturgeon catch increased steadily, from 1,500 pounds to 84,000 pounds. In 1902 a peak Florida catch of 259,000 pounds (117,727 kg; ~117.7 metric tons) was reported. Catch records declined thereafter, reaching only 3,500 pounds by 1945 (McIver 2002).

Catch records exist for some specific Florida Gulf sturgeon fisheries. For example, in Tampa Bay a fishery began in 1886–1887 with a catch of 1,500 fish yielding 5,000 pounds (2,268 kg) of roe, and the following year it produced two thousand fish and 6,300 pounds (2,858 kg) of roe. However, the fishery ended after the 1888–1889 season, when only seven sturgeon were caught (USFWS/GSMFC 1995; Wakeford 2001). Other Florida commercial fisheries were present in the Suwannee River, the Ochlockonee River and Hitchcock Lake, the Apalachicola River, and the Pensacola Bay Basin. Records indicate that these west Florida areas were the only consistent Gulf sturgeon fisheries, with some lasting into the 1980s. Among these fisheries, the Apalachicola River was reported to have been the largest and most productive as of 1901, with 32 families fishing for Gulf sturgeon commercially as late as the mid-1940s. That fishery continued with a few families into the 1970s. The fishery in the Suwannee River was reported to be limited, and lasted from 1899 to 1984, when the state of Florida prohibited catch and possession of Gulf sturgeon. Fish from Hitchcock Lake and the Ochlockonee River were historically shipped to the town of Apalachicola for processing and sale in the New York area. Whereas this fishery was once

believed to be on a scale of that of the Apalachicola River, it largely ended in the early 1970s. In the Pensacola Bay Basin, limited commercial fisheries were reported on the Escambia and Yellow rivers prior to Florida's 1984 ban (USFWS/GSMFC 1995).

Farther west, there are also historical reports of a directed fishery in Alabama, where records of the U.S. Commission of Fish and Fisheries (the predecessor to USFWS) indicated a catch of 100,000 pounds (45,454 kg; ~45.4 metric tons) of Gulf sturgeon in 1903. In Mississippi, according to the Mississippi Department of Wildlife, Fisheries and Parks, 24,000 pounds (10,909 kg; ~10.9 metric tons) of Gulf sturgeon were taken from the Pascagoula River in 1902 (McIver 2002). In Louisiana, a minor commercial fishery for Gulf sturgeon existed in Lake Pontchartrain and its tributaries during the late 1960s (USFWS/GSMFC 1995).

There are presently no commercial or recreational fisheries for the Gulf sturgeon in any part of its range.

Conservation Status and Challenges/Threats

IUCN classified the Gulf sturgeon as Vulnerable in its 2000 Red List, and it was listed as a CITES Appendix II species in 1979 as part of the broader species listing for A. Oxyrinchus (CITES 2001a). The IUCN/SSC Sturgeon Specialist Group is in the process of reassessing the status of North American sturgeon and paddlefish species and stocks for inclusion in an upcoming 2003 Red List of Threatened Species. As of 2001, the proposed listing for the Gulf sturgeon remained as Vulnerable (F. M. Parauka, Gulf Sturgeon recovery Team Member, USFWS, cited in R. St. Pierre, IUCN/SSC Sturgeon Specialist Group, in litt. to IUCN/SSC Wildlife Trade Programme, September 28, 2001). The European Union listed the Gulf sturgeon in Annex B in June 1997 (IUCN 2001; CITES 2001a).

The Gulf sturgeon was listed as Threatened under the ESA in September 1991. Pursuant to that listing, NMFS, USFWS, and GSMFC prepared a management and recovery plan (USFWS/GSMFC 1995). That plan and other sources detailed several challenges or threats to the species.

Historic overfishing. The heavy commercialization of the late nineteenth century, which often went undocumented, is believed to have contributed significantly to the decline of the Gulf sturgeon. As in other sturgeon fisheries, periods of substantial catch appear to have been followed by years of few captures. In addition to commercial catch, "snatch-hook" recreational fisheries in Florida continued into the 1980s, and incidental take has been documented in other fisheries by commercial shrimpers, gill net fishermen, and the industrial bottomfish fishery (for the pet food industry). Because there are no longer targeted commercial fishing operations or recreational fishing for sturgeon allowed in any U.S. range state or in the Gulf of Mexico, the major current threat from exploitation is likely to come from incidental catch (USFWS/GSMFC 1995).

Habitat degradation/restricted range. As an anadromous species with distinct migratory patterns, the Gulf sturgeon evolved with requirements for seasonal high and low flows, temperature regimes, and other factors. Human activities such as dam construction, dredging, channel maintenance, urban development, land management, and others can affect Gulf sturgeon habitat as they do other sturgeon species by blocking and disrupting spawning sites, increasing siltation, and eroding water quality (USFWS/GSMFC 1995; Wakeford 2001).

The effect of dams and other barriers on Gulf sturgeon is exemplified in the Apalachicola River in Florida. There, sturgeon were once believed to migrate as far as 200 miles (322 km) upstream in the Apalachicola-Chattahoochee-Flint River system. Since the 1957 construction of JWLD at river mile 107 (river km 172), however, no tags from extensive tagging studies have been returned from Gulf sturgeon migrating upstream of the dam, and there is no evidence that the species moves through the lock system. Studies in other river systems also show that some dams appear to absolutely block migration of sturgeon, and further degrade or destroy habitat by turning estuarine habitat into freshwater lakes. USFWS/GSMFC (1995) estimated the percentage of remaining habitat after dam, water control structure, or sill construction at 0% in the St. Andrew Bay Drainage in Florida;

22% in the Apalachicola-Chattahoochee-Flint River Basin; 8% in the Alabama River and 12% in the Tombigbee River in the Mobile Bay Basin; 63% in the Pearl River (which is reduced to 10% in low water conditions by the Pool Bluffs Sill at river mile 48.7); 3% in the Bogue Chitto River during low water conditions; and 15% in the Amite River. Randall and Sulak [1999, cited in Wakeford (2001)] also noted that many rivers emptying into northwestern Florida are impounded (Apalachicola and Ochlockonee), diverted (Pea River branch of the Choctawhatchee), or polluted (Fenholloway), and thus provide only limited areas where sturgeon can spawn.

Along with dam construction, navigation-related activities can also affect Gulf sturgeon habitat and spawning. In the Apalachicola River, a deep, rocky area at Rock Bluff (river mile 92.5 [river km 148.8]) frequented by Gulf sturgeon was filled with dredge spoil material from a disposal site one-half mile upstream (USFWS/GSMFC 1995). Siltation and discharges from dams have made some rivers shallower, resulting in a loss of habitat that may have contributed to the reductions in populations of Gulf sturgeon in the Apalachicola and Ochlockonee rivers (Wakeford 2001). Deepening channels, removing river bends, and repeated dredging for channel maintenance may have further eliminated habitat in some river systems important to the species. However, the impacts of such dredging on early life stage habitats of Gulf sturgeon are difficult to assess, because essential habitats of young-of-the-year Gulf sturgeon remain incompletely understood (USFWS/GSMFC 1995).

Another source of environmental stress may be the loss of cool water habitats important to Gulf sturgeon during summer months. Pumping or climate-induced groundwater-level declines can reduce springflow that provides these cool water habitats. For example, one study in the Albany, Georgia, area estimated that about 74% of water pumped from the Upper Floridian aquifer in November 1985 (about 79 million gallons a day) would have discharged to the Flint River under pre-development conditions. This water source is important to the Apalachicola River during low-flow periods. Reduction in base-flow of the Flint River since the early 1970s, primarily because of groundwater and surface irrigation withdrawals, means that this system is providing less water to the Apalachicola River than would normally be expected. Several springs and spring runs along the upper Apalachicola and Flint rivers already exhibit greatly reduced flow or no flow during periods of drought. Loss of such cool water habitats and water sources at critical times during the summer could subject Gulf sturgeon and their habitat to increased stress (USFWS/GSMFC 1995).

Pollution/water quality. Pollution and contaminants may also have contributed to population declines. Gulf sturgeon analyzed from 1985 to 1991 for pesticides and heavy metals showed concentrations of arsenic, mercury, DDT metabolites, toxaphene, PAH, and aliphatic hydrocarbons at levels sufficient to warrant concern [Bateman and Brim (1994), cited in NMFS/USFWS (1998)]. For example, arsenic, which is used in herbicides, insecticides, and fungicides and can be fatal to fish in certain metabolic forms, was found in 92% of Gulf sturgeon samples at a level greater than the Food and Drug Administration (FDA) action limit of 0.50 parts per million. Two or more aliphatic hydrocarbons (components of oils, fuels, and other petroleum products) were detected in all sturgeon tissue samples. Concentrations of PAH found in ovarian tissue samples and eggs in the Apalachicola and Suwannee rivers could impact the development and survival of an undetermined percentage of eggs, larvae, and juvenile fish. The overall impact of these contaminants is difficult to determine, and likely varies by river system (USFWS/GSMFC 1995).

Non-indigenous disease or competition. Accidental release of non-endemic species is considered a threat to ecosystems where viable wild populations of Gulf sturgeon exist, or where the species can possibly be re-introduced. Accidental and intentional releases of exotic species is a frequent occurrence in the range of the Gulf sturgeon, even where laws or regulations prohibit it. In one frequently cited example, white sturgeon were caught in 1989 in Lake Weiss, Alabama, and in 1992 in the Coosa River, Alabama. These sturgeon are believed to have been accidentally released from a private fish hatchery adjacent to the Coosa River in Georgia. The State of Georgia confiscated the hatchery's stock in

1990 (USFWS/GSMFC 1995). Introduction of exotics is believed to pose a particular threat because of the documented ability of different species of Acipenseridae to inter-breed and produce hybrids that could threaten the genetic integrity of wild populations (pers. comm., George Benz, Southeast Aquatic Research Institute [SARI], 2001). There are also questions about the degree to which captive propagation and stocking of hatchery-reared Gulf sturgeon might lead to genetic dilution of distinct river populations, and whether the introduced fish might outcompete or displace native sturgeon and other native fish species in the ecosystem. These concerns are discussed in greater detail in Section VI of this report on Hatcheries and Commercial Aquaculture.

Life history characteristics. As noted briefly above, the Gulf sturgeon appears to exhibit river fidelity and is believed to be a river-specific spawner. Therefore, natural re-population rates may be very low or nonexistent in systems where the species is extirpated or significantly reduced. While immature sturgeon occasionally move between river systems, the long period they require to reach sexual maturity, and the sturgeon's intermittent spawning cycle make it unlikely that the species can establish breeding populations quickly (USFWS/GSMFC 1995). This natural limitation, combined with past failures to protect habitat, manage water resources, control catch, and prevent environmental contamination, poses a significant challenge the recovery of the species.

3.3 Shortnose Sturgeon *(Acipenser brevirostrum)*

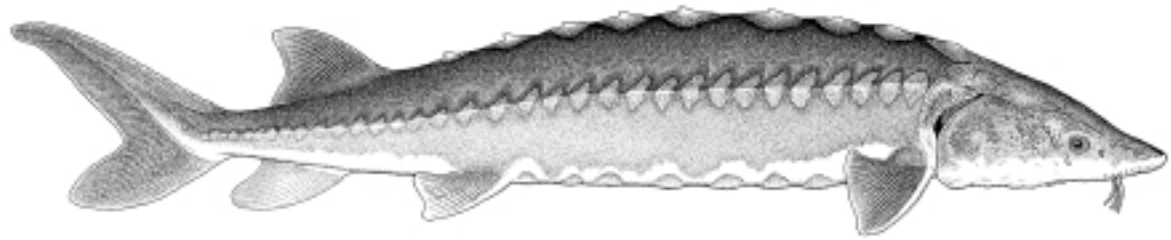


Illustration by Paul Vecsei

The shortnose sturgeon is a small, anadromous fish that shares many of the same rivers and estuaries inhabited by the much larger Atlantic sturgeon along the eastern coast of North America. The two species do not, however, compete. Differences in their life cycles, seasonal movements, and habitat preferences allow the two species to coexist. They do share many of the same threats and challenges; the shortnose sturgeon is believed to have been a frequent casualty of past efforts to exploit the more economically valuable Atlantic sturgeon. In 1967, the shortnose sturgeon became the first acipenseriform species to receive federal protection in the United States when it was listed as endangered.

Historic Range and Current Distribution

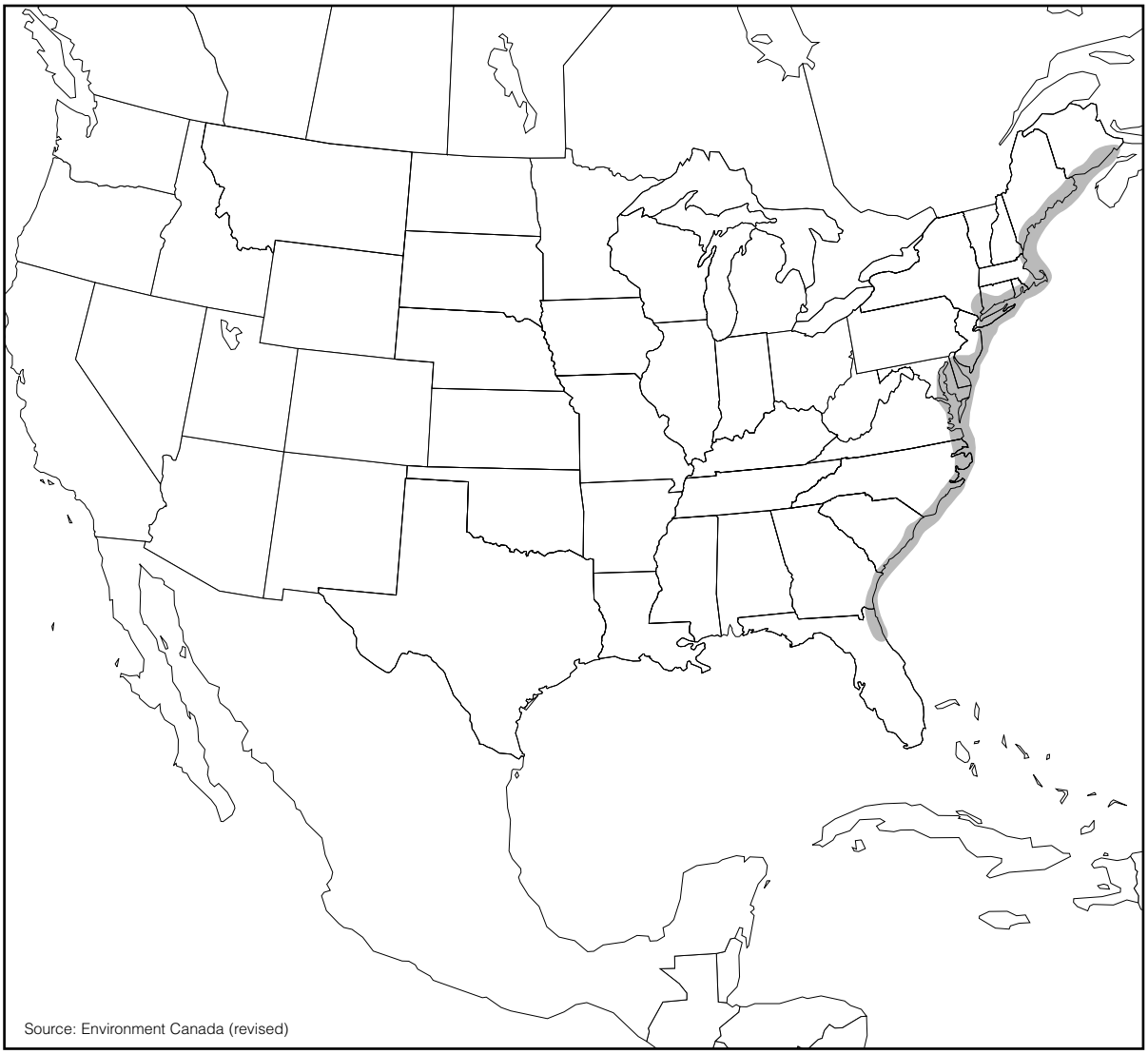
Historically, shortnose sturgeon are believed to have inhabited rivers and estuaries along nearly the entire east coast of North America. The northern extent of this range was the Saint John River in New Brunswick, Canada, while the southern part extended to the Indian River in Florida (NMFS 1998). Figure 3 shows the range of the shortnose sturgeon.

Similar to its range-mate, the Atlantic sturgeon, the present range of the shortnose sturgeon has contracted somewhat from historical times. The species is now believed to consist of 19 distinct population segments occurring in 25 river systems, ranging from New Brunswick's Saint John River to Florida's St. Johns River. In a 1998 Final Recovery Plan for the Shortnose Sturgeon, NMFS cited available population estimates indicating that the smallest number of adult fish occur in the Merrimack River in Massachusetts and the Cape Fear River in North Carolina, while the largest populations reside in the Hudson River in New York and the Saint John River in New Brunswick (NMFS 1998).

Canada's shortnose sturgeon population is largely concentrated in the Saint John River. A mark-recapture effort conducted in the river between 1973 and 1977 produced a population estimate of approximately 18,000 fish [Dadswell (1979), cited in NMFS (1998)]. A more recent 1992 survey found the catch-per-unit effort unchanged from that earlier work, indicating that the population remained relatively stable into the 1990s (NMFS 1998). Since 1997, a team from the University of New Brunswick has been working to determine the status of the shortnose sturgeon in the Kennebecasis River, a tributary of the Saint John River, including its habitat needs, population size, distribution, and spawning habitat. Through a mark-recapture study, the team determined that there are nearly 4,000 adult shortnose sturgeon in the Kennebecasis River. Researchers have been tracking the fish with sonic tags to learn about their movements in this habitat through the summer, fall, and winter, and have located the first spawning grounds. Research is continuing in order to identify crucial habitat components (Environment Canada 2000; WWF-Canada 2001).

In the northeastern United States, a distinct shortnose sturgeon population is believed to occur in Maine's Penobscot River, and archaeological data suggest that native peoples used sturgeon from that river. However, a directed survey for shortnose sturgeon conducted in 1994 and 1995 in the Penobscot River at the head of the tide failed to capture

Figure 3 Shortnose Sturgeon Range



any of the species. It is further believed that discharge rates and river depths in some of the small coastal rivers between the Kennebec and Saint John rivers, such as the Dennys, Machias, East Machias, and Ducktrap rivers, may not be sufficient to support shortnose sturgeon populations (NMFS 1998).

Shortnose sturgeon are known to occur in the estuarine complex formed by Maine's Sheepscot, Kennebec, and Androscoggin rivers. A sturgeon tagging effort from 1977 to 1980 produced an estimate of 7,222 adults for this complex. Additional tracking studies to delineate spawning habitat were performed in the Androscoggin River in 1993. Gill net catch-per-unit effort during that study was the highest recorded in this area, suggesting that the Androscoggin population had increased since the earlier survey (NMFS 1998). It is hoped that the July 1999 removal of the Edwards Dam on the Kennebec River will restore upstream access to historic habitat and spawning grounds for shortnose sturgeon and other anadromous species (Maine Rivers 2000).

Continuing south, there are no known shortnose sturgeon populations between the Androscoggin and Merrimack rivers, indicating that the species is not found in river systems such as the Royal, Presumpscot, Saco, Kennebunk, or York rivers. However, the

lower salinity reaches of these rivers may not have been adequately sampled, so the complete absence of the species is not certain. There is a small population found in the Merrimack River of New Hampshire and Massachusetts, estimated in the NMFS Recovery Plan to be 33 adult fish. This estimate may change with further research (NMFS 1998).

While Dadswell et al. (1984) indicate that shortnose sturgeon once occurred in coastal waters in Rhode Island, eastern Connecticut, and Narragansett Bay, there are currently no known populations between the Merrimack and Connecticut rivers. In the Connecticut River, the Holyoke Dam separates the population into an upriver population above the dam and a lower river group between the dam and Long Island Sound. Mark-recapture studies cited by NMFS (1998) produced estimates ranging from 297 to 714 adult sturgeon and a spawning population of 47 and 98 sturgeon for the years 1992 and 1993, respectively. The mean population estimate for the lower river was 875 adults, although this number was thought to have possibly been high because the lower river is not closed to downstream migration of upper river fish. A more recent estimate for the Connecticut River considered the population to be stable at 1,200 to 1,500 individuals (USFWS 2000a).

From the Connecticut River south and west, no shortnose sturgeon populations are known to exist until New York's Hudson River. The Hudson River population, which is located only in the lower portion of the river from the southern tip of Manhattan (river mile 0) upriver to the Federal Dam at Troy (river mile 152), is believed to be the largest in existence, with a 1995 estimate of approximately 38,000 adults [Bain et al. (1995), cited in NMFS (1998); New York State Department of Environmental Conservation (2001)]. That population figure far surpassed one found by mark-recapture studies conducted in 1979 and 1980, which produced an estimated spawning population of 13,000 adults [Dovel (1979), cited in NMFS (1998)]. The larger estimate suggested a two- to four-fold increase in adult shortnose sturgeon in the Hudson River over the past decade (NMFS 1998). A more recent four-year study estimated a Hudson River population of 56,708 adult fish, more than 400% larger than the estimate for the late 1970s, indicating a substantial level of success in this particular population's recovery (Bain et al. 2001).

No shortnose sturgeon populations are known to occur in New Jersey coastal waters from the Hudson River to the Delaware River, and not enough information about the Delaware River population was available at the time of this report to accurately assess its status. Between 1981 and 1984, three estimation procedures produced estimates ranging from 6,408 to 14,080 sturgeon, but model assumptions may have been violated (NMFS 1998).

There is historical evidence dating back as far as the nineteenth century indicating the presence of shortnose sturgeon populations in the Chesapeake Bay and its tributaries. Areas where shortnose sturgeon have been captured or observed include the Potomac River, the upper Bay near the mouth of the Susquehanna River, and the lower Bay near the mouths of the James and Rappahannock rivers (NMFS 1998). Thirty-two shortnose sturgeon were captured by commercial fishermen in Maryland waters of the Chesapeake Bay between January 1996 and September 1999 during a reward program for Atlantic sturgeon. This is more than twice the number reported from the Bay between 1876 and 1995; however, few data are available on population dynamics, historic distributions, or movement. Information from the reward program and sonic tagging of shortnose sturgeon in the Chesapeake Bay and Delaware River indicated that the species was primarily distributed in the upper portions of the Bay, with individuals displaying wandering, localized, and upstream movements. One individual was tagged within the Chesapeake Bay and later relocated in the Delaware Canal and Delaware River, suggesting that the species may traverse the Chesapeake and Delaware Canal, and shortnose sturgeon in the Bay may be transients from the Delaware River population (Welsh et al. 2000).

Moving into the southeastern United States, there are historic accounts but no definitive information on population dynamics for the species in the Albemarle Sound and Roanoke and Chowan rivers, as well as the Pamlico Sound and North, New, and Neuse rivers. An extensive sampling program confirmed the presence of shortnose sturgeon in North

Carolina's Cape Fear River. The nine specimens that were captured were all adults; no juveniles were found. Damming of the river in the coastal plain, channelization, and the existence of heavy industries may threaten this population segment, which probably numbers fewer than 50 fish [Moser and Ross (1995), cited in NMFS (1998)].

Similarly, shortnose sturgeon have been documented in the Winyah Bay system, which is fed by the Waccamaw, Pee Dee, and Black rivers; the Santee River; the Cooper River; and the Ashepoo, Combahee, and Edisto rivers. However, the population status, distribution, and dynamics of all of these potential populations had not been extensively researched and documented at the time of this report (NMFS 1998).

The Savannah River along the South Carolina/Georgia border contains a confirmed population of shortnose sturgeon, with some 600 adults captured by shad fishermen and researchers between 1984 and 1992. A high ratio of adults to juveniles suggested that recruitment was low at the time, possibly because the river is dammed, and other hydrographic conditions may have changed. Adults in the river are believed to spawn in late winter well upriver in the approximate area of river miles 107 to 170 (river km 179–278), but spend the rest of the year in the vicinity of the fresh/brackish water interface [Collins and Smith (1993), cited in Collins et al., 2001). Between 1984 and 1992, approximately 97,000 shortnose sturgeon of various sizes were stocked in the river to evaluate the potential for stock enhancement, and subsequent research indicated that stocked fish accounted for 41% of all juvenile sturgeon collected (NMFS 1998).

During 1999 and 2000, 57 shortnose sturgeon were captured during a survey undertaken to evaluate the status, distribution, and recruitment of the species, in particular juveniles, in the Savannah River. Fifteen juveniles and 17 adults were implanted with acoustic transmitters to determine their movements and habitat utilization patterns. The study found that when water temperatures were less than 71.6° F (22° C), juveniles concentrated in the vicinity of the intersection of the Front and Middle rivers at river mile 18.6 (river km 31), and moved about in both these rivers. When temperatures exceeded 71.6° F, the juveniles moved well upriver, concentrating especially around river mile 28.5 (river km 47.5). Adults also moved upriver when temperatures were high, and during low temperatures again relocated to the vicinity of the Front/Middle River intersection. However, some adult fish also moved further downriver almost to the river mouth during this period. Between 1988 and 1992, it had been observed that juveniles concentrated in Kings Island Turning Basin at river mile 18.6 (river km 31). It appeared during the 1999–2000 study that harbor modifications since 1992 had changed the hydrographic conditions and caused the fish to move from that area (Collins et al. 2001).

A separate study of adult abundance in the Savannah River resulted in evidence that the population in 2000 was larger than that in 1992. However, this is believed to be attributable to the stock enhancement program conducted during 1985–1992 rather than to natural expansion of the population. The low catch rate of juveniles during the 1999–2000 survey suggests that natural recruitment is still quite low (Collins et al. 2001).

In the undammed Ogeechee River, a survey of shortnose sturgeon occurrence, distribution, and abundance was conducted from 1993 to 1995 in the tidal portion of the river drainage, which found low abundance and a population dominated by adults. The highest estimate for this population in 1993 was less than 400 sturgeon of all age classes combined. Size frequency, abundance, and catch rate data indicated that the Ogeechee population may have been experiencing higher juvenile mortality rates than those found in the nearby Altamaha River, which drains the largest watershed east of the Mississippi River. Data collected during studies in the early 1990s indicated that abundance in the Altamaha River system did not exceed 6,055 fish of all size and age classes, and may be well below that. However, it is believed that the Altamaha River population segment is the largest and most viable population south of Cape Hatteras, North Carolina (NMFS 1998).

South of Georgia's Altamaha River, shortnose sturgeon were collected in the estuaries of the Satilla and St. Marys rivers during the late 1980s and early 1990s. Similarly, small

numbers of shortnose sturgeon were found in the late 1970s and early 1980s in Florida's St. Johns River. More recent surveys failed to capture any shortnose sturgeon in the St. Marys or Satilla systems, and the current status of the population segment in the St. Johns River is unknown (NMFS 1998).

Ecology and Habitat

The shortnose sturgeon is the smallest of the three East/Gulf coast sturgeon species in North America. Its maximum length is about 4 feet (1.4 meters) and its maximum weight is about 50 pounds (23 kg). As with the Atlantic sturgeon, its growth rate and maximum size vary with latitude, with the fastest growth among southern populations. The oldest known female specimen was recorded at 67 years, although males seldom exceed 30 years (NMFS/NOAA 2001b; Hochleithner and Gessner 1999; Chapman 1999).

Males are estimated to reach sexual maturity at 5 to 12 years of age, and females at 6 to 18 years of age. It is generally believed that northern populations mature more slowly than do southern populations. For example, it has been estimated that females mature at age six or even earlier in Georgia, six to seven from South Carolina to New York, and at age 13 or later in Canada's Saint John River. Initial spawning occurs in males one to two years after they reach maturity, but in females initial spawning can be delayed up to five years, especially in northern populations. Spawning generally takes place in cycles of 2–3 years in males, although some may spawn every year, and 3–8 years for females, with the margin again increasing in northern latitudes (NMFS/NOAA 2001b; Hochleithner and Gessner 1999).

Spawning migrations are believed to take place in the fall, and the sturgeon overwinter near their spawning grounds. Although the timing of spawning varies among river systems, it is generally believed to take place between March and June, when the water temperature increases to a suitable level, and lasts for varying lengths of time. Spawning sites are characterized by gravel or rocky bottoms and a current velocity of 1.3 to 2.0 feet per second (0.4 to 0.6 meters per second). Spawning has also been observed in the tidal sections of estuaries (Hochleithner and Gessner 1999).

Hochleithner and Gessner (1999) estimated the number of eggs per kilogram of body weight for female shortnose sturgeon at 11,000 to 12,000. Chapman (1999) provided a broader estimate of 9,000 to 16,000. The average diameter of ripe eggs is 3.0–3.2 mm (Hochleithner and Gessner 1999; Chapman 1999). At hatching, shortnose sturgeon are approximately 7–11 mm long and blackish-colored. In 9–12 days the young absorb their yolk-sac and develop into larvae at about 15 mm in length. At about 20 mm, larvae begin to resemble adults and probably migrate downstream, where they begin to undertake a residency period in deep water. Juveniles occur in the saltwater/freshwater interface in most rivers inhabited by the species, although there are variations (NMFS 1998; Hochleithner and Gessner 1999).

The shortnose sturgeon is similar to the Atlantic sturgeon in that it is anadromous. However, unlike the Atlantic sturgeon, the shortnose sturgeon spends most of its life cycle in slow-moving riverine waters or near-shore marine waters rather than in the open ocean. Shortnose sturgeon populations are confined primarily to natal rivers and estuaries, with adults migrating seasonally into marine waters (Environment Canada 1999; Hochleithner and Gessner 1999; NMFS/NOAA 2001b). In addition, while shortnose sturgeon appear to be estuarine anadromous in the southern portion of their range, in some northern rivers they are considered freshwater amphidromous, with adults living and spawning in fresh water, but regularly entering saltwater environments. Some northern populations (for example in the Hudson and Connecticut rivers) also have freshwater forms (NMFS 1998; Hochleithner and Gessner 1999).

Shortnose sturgeon are benthic omnivores. Juveniles are believed to feed on benthic insects and crustaceans, while molluscs and large crustaceans comprise the primary food for adults. They have also been observed feeding off plant surfaces. Based on a high incidence of non-food items found in a study of juveniles (Dadswell et al. 1984), researchers concluded that juveniles randomly vacuum the

bottom, while adults are more selective. The presence of food in the gut at all times of the day indicates that shortnose sturgeon are continuous feeders [Dadswell (1979), cited in NMFS (1998)].

Historic Fisheries/Catch Levels

There are few records of historic catch levels for shortnose sturgeon. In part, this is because sturgeon catch records for the Atlantic Ocean around the beginning of the twentieth century did not differentiate between shortnose sturgeon and Atlantic sturgeon (Waldman 1999; Friedland 2000). The shortnose sturgeon was not a principal target of the commercial fishery, but may have been taken frequently as bycatch in the Atlantic sturgeon fishery. During the 1950s, the decline of all sturgeon fisheries on the East coast of North America led to a further lack of data regarding shortnose sturgeon. By 1967, USFWS had concluded that the species was extirpated from much of its range and in danger of extinction (NMFS/NOAA 2001b).

Conservation Status and Challenges/Threats

IUCN's Red List 2000 listed the shortnose sturgeon as Vulnerable (IUCN 2001). The species was listed in Appendix I of CITES in January 1975, although Canada maintained a reservation until September 1977. The European Union listed the species in Annex A in June 1997 (CITES 2001a).

The shortnose sturgeon was listed as endangered in the United States on March 11, 1967 (32 FR 4001), and the species remained on the endangered species list when the ESA came into force in 1973 (NMFS 1998). In 1980, Canada placed the species in its "Special Concern" risk category (Environment Canada 2000).

Some of the major challenges to the shortnose sturgeon's recovery are as follows.

Incidental catch and poaching. While directed fishing for shortnose sturgeon is now prohibited in the United States, the species is taken incidentally in other fisheries along the East coast, and may be targeted by poachers as well. Commercial and recreational shad fisheries in the Merrimack, Connecticut, Hudson, Delaware, and Cape Fear rivers, as well as various rivers in South Carolina and Georgia, are known to capture shortnose sturgeon. In Georgia, the shad gillnet fishery accounted for 83% of reported shortnose incidental take [Collins et al. (1996), cited in NMFS (1998)]. Moser and Ross (1993) reported that incidental take in shad nets disrupted spawning migrations in the Cape Fear River, and Weber (1996) reported that incidental captures caused abandonment of spawning migrations in the Ogeechee River in Georgia (both cited in NMFS 1998). In Canada's Saint John River estuary, shortnose sturgeon are taken incidentally in shad, salmon, striped bass, and alewife fisheries. The percentage of incidental sturgeon take in the shad fishery is large, perhaps because the sturgeon spring migration coincides with the shad fishing season (NMFS 1998).

The impact of poaching is unknown, but may be significant in some rivers. In 1995, two South Carolina fishermen were apprehended with five pounds of shortnose sturgeon roe and two gravid fish (NMFS 1998). Illegal trade is discussed in greater detail in Section V of this report.

Habitat degradation/restricted range. Direct and indirect impacts from bridge construction, dams, dredging, and power plant reservoir operations have all been identified as conservation challenges to shortnose sturgeon populations. For example, sediments emanating from bridge construction and demolition projects may result in siltation in downstream spawning sites, thereby affecting egg survival. In addition, blasting during the construction or demolition of bridge piers can produce shock waves that damage the species' air-bladder, leading to the risk of mortality. Mitigation efforts using an air-gap (such as double-wall cofferdam or bubble screen) placed around piers and similar support structures during blasting may reduce this risk, but the impact is not well documented (NMFS 1998).

Hydroelectric dams can restrict habitat, alter river flows or temperatures necessary for successful spawning and/or migration, and entrain fish in turbines. In all but one northeastern U.S. river supporting shortnose sturgeon, the first dam on the river marks the upstream limit of the population. The exception is the "dam-locked" population above the Holyoke Dam on the Connecticut

River. In all of these rivers, spawning sites occur just below the dams, leaving all life stages vulnerable to changes in natural river conditions caused by dam operations. Shortnose sturgeon do not appear capable of using fishways (ladders), but have been moved in fish lifts. This inability to move above dams to potential spawning habitats may restrict population growth. Dam maintenance activities, such as excavations, also release silt that can be deposited in nearby spawning sites, further degrading habitat (NMFS 1998).

Dredging to maintain navigation channels can impact shortnose sturgeon directly by entraining them in dragarms and impeller pumps, and indirectly by destroying feeding areas, disrupting migration, and blanketing spawning habitat with fine silt. In 1991, NMFS concluded that an Army Corps of Engineers' dredging operation in the lower Connecticut River was likely to jeopardize the resident shortnose sturgeon population, because the project was scheduled for early summer, used a hydraulic hopper dredge, and involved in-river dredge-spoil disposal within high-use feeding areas. The impacts of such activities can be mitigated by changing the timing of the project to avoid the presence of sturgeon in the area, or using different equipment. However, cases of shortnose sturgeon mortality in the Cape Fear River and Delaware River have demonstrated that other dredging methods such as hydraulic pipeline and buck-and-barge operations may also adversely affect sturgeon (NMFS 1998).

Electric power and nuclear power plants can impinge larger sturgeon on cooling water intake screens and entrain larval fish. Plant construction and operation activities such as excavation, dewatering, and dredging can also affect sturgeon habitat by producing excessive turbidity and destroying habitat and food resources. Plant shutdowns to repair clogged water intake gates and remove decomposing plant material can also trigger low dissolved oxygen conditions in waters downstream, leading to fish kills. Without better data on current shortnose populations, it is not possible to determine the effects of such operations and specific impacts on local sturgeon populations (NMFS 1998).

Reservoir operations can affect shortnose sturgeon and other species downstream in two opposite but potentially harmful ways. One potentially harmful operation relates to unplanned but controlled water releases that can diminish or reduce spawning success by artificially extending high flow periods during periods when water temperatures are ideal for spawning. The other potential problem is the abrupt termination of discharge periods, resulting in lethal anoxic conditions downstream (NMFS 1998).

In addition, during summer months shortnose sturgeon, like other sturgeon species, relieve physiological stress during periods of high water temperatures by seeking out thermal refuges in deep, artesian spring-fed habitats. Loss and/or manipulation of these areas may affect survival, especially in southern river systems more prone to warm water conditions. As with the Gulf sturgeon, the depletion of subterranean aquifers in rivers such as the Savannah, Ogeechee, Satilla, and St. Marys may impact critical habitat necessary for survival and lead to high mortality among juveniles or even the ability to support shortnose populations at all. This may currently be the case in the Satilla and St. Marys rivers (NMFS 1998).

Pollution/water quality. Toxic metals, PAH, pesticides, and PCBs can produce acute lesions, growth retardation, and reproductive impairments in marine life. Lifespan characteristics of the shortnose sturgeon (long lifespan, extended inhabitation of estuaries, benthic feeding) predispose the species to the effects of long-term and repeated exposure to such contaminants. Unfortunately, there have been very few studies to assess the impact of contaminants on shortnose sturgeon populations, but it is suspected that increased levels of environmental contaminants are associated with reproductive impairment, reduced egg viability, and reduced survival of larval fish, leading to poor recruitment (NMFS 1998).

Point-source discharges (municipal wastewater, paper mill effluent, industrial and power plant cooling and wastewater) may also contribute to further impacts on sturgeon populations (NMFS, 1998). Pulp mill, silviculture,

agriculture, and sewage discharges are known to reduce dissolved oxygen levels. Reduced water flows from power plant shutdowns can also produce anoxic conditions downstream. Jenkins et al. (1993), cited in NMFS (1998), reported that juvenile shortnose sturgeon experienced high mortality rates (86%) when exposed to extremely low dissolved oxygen levels, while older fish exhibited increased tolerance (< 20% mortality). It is believed that extremely low dissolved oxygen levels may explain the failure to capture shortnose sturgeon in the St. Marys and Satilla rivers during recent surveys (NMFS 1998).

Non-indigenous disease or competition. Rapid increases in the abundance of non-indigenous species such as Asian clams, zebra mussels, and blue and flathead catfish are considered likely to adversely affect the abundance of shortnose sturgeon prey and/or introduce new competitors or predators. In addition, introductions and transfers of indigenous and non-indigenous sturgeons may pose genetic threats, increase competition for food or habitat, or spread exotic diseases. As with the Gulf sturgeon, there is concern about the introduction of west coast sturgeon species and the possible introduction of diseases previously unknown in shortnose sturgeon but highly prevalent in white sturgeon aquaculture facilities (NMFS 1998). As described in Section VI of this report on Hatcheries and Commercial Aquaculture, there are also questions about the possible impact on wild stocks of captive propagation and stocking programs.

3.4 North American Paddlefish *(Polyodon spathula)*

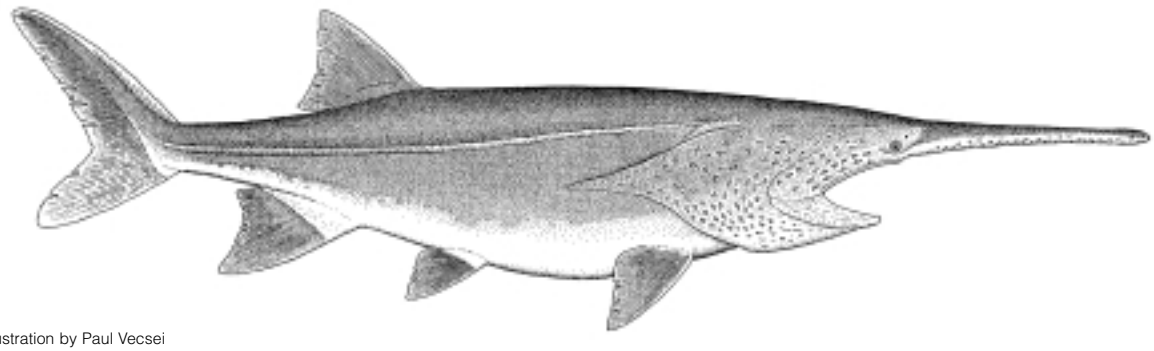


Illustration by Paul Vecsei

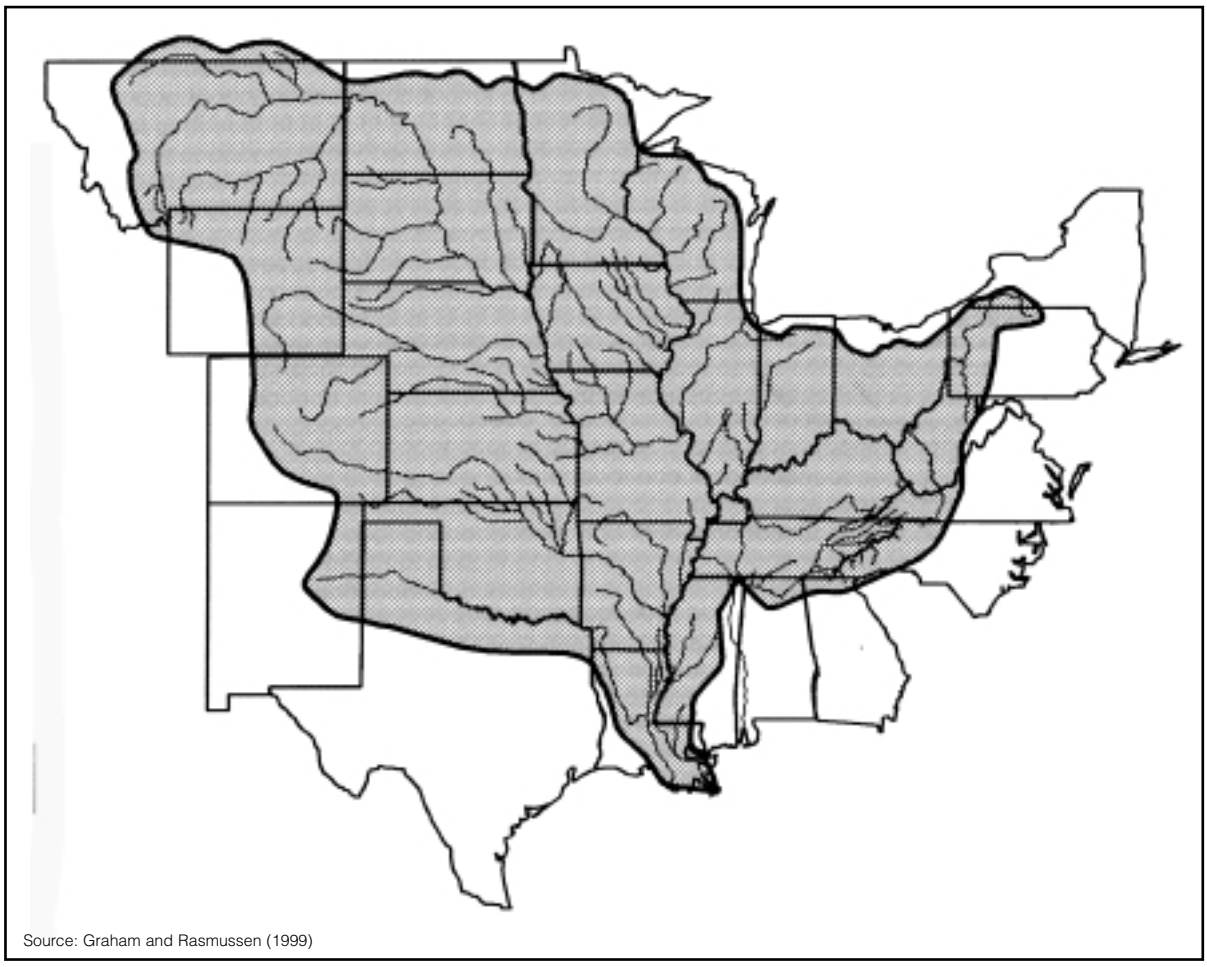
The North American paddlefish is one of two living paddlefish species in the world. The only other member of the family Polyodontidae is the Chinese paddlefish (*Psephurus gladius*), which occurs in China's Yangtze River and its tributaries in Asia. The American paddlefish has a number of common names, including the "spoonbill," "spoonbill cat," "shovelbill cat," "duckbill cat," "shovelnose cat," "spoonbill sturgeon," "spadefish," "boneless cat," "freshwater sturgeon," "Chattanooga beluga," "American sturgeon," and even "freshwater whale" because of its behavior as a filter feeder (Russell 1986; Anon. 2000a). The species is at the center of the debate over the future of North American Acipenseriformes because of the value of its caviar as a potential substitute for Caspian Sea sturgeon roe.

Historic Range and Current Distribution

Paddlefish were once widely distributed throughout the Mississippi River, Missouri River, and adjacent Gulf Slope drainages, as well as in the Great Lakes and some southern Ontario waters in Canada (Gengerke 1986; Environment Canada 2001a). The current distribution of the paddlefish, while still broad, is reduced from its historic range. Major tributaries of the Mississippi and Missouri rivers with paddlefish populations include sections of the Red, Arkansas, White, Tennessee, Cumberland, Ohio, Wabash, Missouri, Platte, and Yellowstone rivers (Hochleithner and Gessner 1999). Paddlefish are also present in the Mobile Bay–Alabama River drainage; however, Gengerke (1986) indicated that this population was not considered abundant. Data from many river systems are too incomplete to determine an overall abundance level or to make possible individual summaries of many current populations. Figure 4 shows the species' historic distribution.

There has been widespread discussion and debate about the presence and status of paddlefish populations in various U.S. states. Paddlefish populations today occur in at least 21 states: Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Montana, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, Texas, West Virginia, and Wisconsin. Paddlefish are no longer present in Canada, and in the United States natural paddlefish populations are considered extirpated in Maryland, New York, North Carolina, and Pennsylvania (Gengerke 1986; Graham 1997; Hesse and Carreiro 1997). Gengerke (1986) reported the presence of the species in Virginia's Clinch River flowing into the Norris Reservoir. However, more recently the state reported only historic anecdotal reports of occurrences, and the species' continued presence in Virginia is unknown (Gary Martel, Director, Fisheries Division, Virginia Department of Game and Inland Fish, in litt. to Teiko Saito, USFWS/OMA, August 22, 2000). Hesse and Carreiro (1997) cited Lee et al. (1980) as indicating that paddlefish may have also been present at one time in Georgia and Michigan. With a few exceptions, the reduction of the species' range has been confined to peripheral reaches of historic paddlefish distribution (Gengerke 1986).

Figure 4 Historic Paddlefish Range



Source: Graham and Rasmussen (1999)

Hesse and Carreiro (1997) reported deteriorating paddlefish populations in Arkansas, Iowa, Minnesota, Mississippi, and portions of South Dakota; stable populations in Alabama, Illinois, Indiana, Louisiana, Kentucky, Missouri, Montana, Nebraska, North Dakota, and Oklahoma; and population increases in at least portions of the species' range in Kansas, Oklahoma, South Dakota, and Texas. Hesse and Carreiro reported that no firm data were available on the overall status or trends of known paddlefish populations in Illinois, Missouri, Mississippi, Montana, Ohio, and Wisconsin. Tennessee did not respond to that survey, and data were reported as inconclusive in West Virginia.

Some paddlefish populations have been reported as increasing because of restoration programs. Graham and Rasmussen (1999) indicated that this trend has been especially notable in the periphery of the species' native range. For example, Kansas, Louisiana, New York, Oklahoma, Pennsylvania, South Dakota, Texas, and West Virginia have stocked paddlefish to bolster natural reproduction or reclaim natural populations (although Texas recently ceased stocking). These programs, as well as a summary of other states that at one time stocked paddlefish but no longer do so, are discussed in greater detail in Section VI on Hatcheries and Commercial Aquaculture.

An interesting characteristic of the paddlefish concerns the fact that, while the species is believed to have been extirpated from some historical range waters (e.g. the Tombigbee River, Swan Lake, Big Sioux River, Little Sioux River, Kankakee River, Lake Erie, Namakan River, Shawnee Creek, and Bois d'Arc Creek), the fish have successfully colonized others (e.g., Smoky Hill River,

Wakarusa River, Turtle Creek Reservoir, John Redmond Reservoir, Des Moines River, Black River, Harry S. Truman Reservoir, Lake of the Ozarks, Salt River, Merimac River, and Current River) (Hesse and Carreiro 1997). As Section VI details, some of this colonization can be attributed to stocking efforts.

A considerable and perhaps inevitable dispute is ongoing between fisheries managers and commercial fishermen about the status of paddlefish stocks in a number of states. For example, while states such as Alabama and Louisiana have closed their commercial fisheries to conserve paddlefish stocks, some commercial fishermen argue that the species is abundant in many rivers and other water bodies in those states and should be open to catch (pers. comm., interviews with Tennessee commercial fishermen, 2001). Because of the significant interest in paddlefish and the complicated nature of the debate over its present distribution and status, more detailed information on individual state populations of paddlefish is included in Section IV of this report.

Ecology and Habitat

The paddlefish is readily distinguished from other fishes by its elongated rostrum, or "paddle," that is approximately one third the length of its body. Newly hatched young do not have this rostrum, which starts growing in one to two weeks and is largely developed in four to five weeks. The function of the rostrum is not fully understood (Russell 1986).

Paddlefish can reach up to seven feet (2.3 meters) in length and about 175 pounds (80 kg) in weight. Males reach sexual maturity at 5–9 years of age, while females reach sexual maturity at 8–12 years of age. Subsequent spawnings are reported in males every one to two years and in females every two to four years (Hochleithner and Gessner 1999). Russell (1986) noted that fish up to 30 years of age have been reported, and paddlefish older than 15 are common in many populations. Scarnecchia and Graham (1999) reported that paddlefish in southern U.S. stocks tend to mature faster than those in northern stocks, but they also exhibit far shorter lifespans.

Paddlefish inhabit the moderate flow of large rivers that provide high zooplankton production (Hochleithner and Gessner 1999). In the late 1800s and early 1900s, before the large, free-flowing rivers of the Mississippi drainage were altered, the naturally braided channels, extensive backwater areas, and oxbow lakes of these river systems provided ideal habitat and supported large paddlefish populations. Adults were usually found in the slower moving waters of the rivers, and sometimes in small tributaries. During spring rises, paddlefish moved into bayous and river-lakes, where most remained as long as the connections with the rivers remained (Russell 1986).

In the roughly 100 years since damming and channelization began in most of these major river systems, alterations have increased water currents, altered natural flow and temperature regimes, and eliminated spawning areas, backwaters, and other preferred habitat. In altered rivers, paddlefish are reported to concentrate in sheltered areas such as pools below sandbars, near physical features like big islands, or near shore irregularities where flow velocity is reduced. They may also gather near man-made structures such as dikes, revetments, and bridge supports, where these structures or associated scour holes reduce current. Along with riverine habitat, the paddlefish is also commonly found in reservoirs, where the species often congregates near dams just below the spillway (Russell 1986).

Spawning migrations occur in spring at high water, with adult paddlefish sometimes traveling hundreds of miles to reach spawning grounds. Paddlefish are believed to require a precise timing of events for spawning to be successful. Spawning itself takes place over gravel or rocky bottom from March to June when water temperature, water flow, current velocity, light intensity, and substrate meet the biological requirements of the species (Russell 1986). Paddlefish require water temperatures in the mid-50° F (12–18° C), a river stage of 10 feet (~3 meters), and a minimum flow velocity of 3.3 feet per second (1 meter/s). Photoperiod and water temperature control timing, but increase in flow velocity is believed to be the triggering stimulus for spawning activity (Russell 1986; Hochleithner and Gessner 1999). Mating has been observed in groups in the evening. Hochleithner and Gessner (1999) reported a female fecundity range of between 15,000 and 20,000 eggs per kg, with egg diameters of 3.3 to 3.9 mm.

Unspent eggs are reabsorbed during the descending migration, or if correct physical parameters for spawning are not available. Adult paddlefish move in groups immediately after spawning (Russell 1986; Hochleithner and Gessner 1999).

Paddlefish food consists primarily of zooplankton, especially copepods and insect larvae, which the fish catch by swimming with their mouths wide open. Paddlefish filter food items from the water through the buccal cavity, using the gill rakers (Hochleithner and Gessner 1999).

Historic Fisheries/Catch Levels

Paddlefish were of little economic importance prior to the late 1800s, although commercial catch was significant. In 1894, approximately 1 million pounds (450,000 kg; 450 metric tons) of paddlefish were taken, but the catch was valued at only $21,000. The fishery concentrated primarily upon meat, although the roe brought fishermen 35–40 cents per pound (Pasch and Alexander 1986). As excessive catch of Atlantic and lake sturgeons led to the decline of fisheries for those species, paddlefish became more widely valued and pursued. Pasch and Alexander (1986) and Waldman (1999) reported that landings peaked at 2.4 million pounds (~1.09 million kg; 1,000 metric tons) in 1899, but then dropped to 1.4 million pounds (~636,000 kg; 636 metric tons) by 1903. Russell (1986) cited Coker (1930) in reporting that the total commercial catch in 1897 was 2.5 million pounds (~1.14 million kg; 1,140 metric tons).

Paddlefish caviar reached parity with sturgeon caviar in the first two decades of the twentieth century at about $1.50 to $3 per pound (~70 cents to $1.35 per kg). Specific data are sporadic, but Waldman (1999) cited Pasch and Alexander (1986) to note an overall decline in catch of 30% through 1950. Gengerke (1986) reported that by 1931 catch dropped to 108 tons (216,000 pounds; 98,180 kg; ~98 metric tons), a 90% drop from 1899. Catches increased sharply during World War II when imports of sturgeon products were reduced, and Pasch and Alexander (1986) reported that over 700,000 pounds (~318,000 kg; 318 metric tons) of paddlefish were taken from the Wilson and Wheeler reservoirs in Alabama and sold in large city markets in 1941 and 1942. Nationwide commercial catch for this period was not recorded, but may have reached levels reported earlier in the century. It is believed that some caviar was being produced, but probably did not command the prices it once did (Pasch and Alexander 1986; Waldman 1999).

Between 1965 and 1975, Pasch and Alexander (1986) and Waldman (1999) estimated that national paddlefish catch levels were about 500,000 pounds (227,000 kg; 227 metric tons) per year, while the price of roe remained low at 25 cents to $2 per pound (~11 to 90 cents per kg). Russell (1986) cited Carlson and Bonislawsky (1981) in providing an estimate of 530,000 pounds (~240,000 kg) annually, with approximately 40% of the catch in the Tennessee River. Gengerke (1986) reported that by 1975 commercial catch in the Mississippi River had declined about 95% from that reported around 1900.

It is believed that many commercial fishermen during this period discarded roe. However, by 1979 the price for salted, bulk-packed roe had risen to $12 to $15 per pound ($5.40 to $6.75 per kg), making a gravid female worth more than $200 for eggs alone. Fishing pressure once again rose; for example, more than 750,000 pounds (~340,000 kg; 340 metric tons) dressed weight was taken in 1980 from reservoirs on the Cumberland and Tennessee rivers alone (Pasch and Alexander 1986; Waldman 1999).

Among the seven U.S. states that currently allow commercial catch of paddlefish (Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee), declines in commercial catch were recorded between 1989 and 1997 in Illinois, Missouri, and Tennessee. In Illinois the reported commercial catch was 161,641 pounds (73,473 kg) in 1989, but only 49,036 pounds (22,289 kg) in 1997. Missouri's reported landings went from 56,870 pounds (25,850 kg) in 1989 to 9,790 pounds (4,450 kg) in 1996, and Tennessee's from 485,342 pounds (220,610 kg) in 1990 to 64,704 pounds (29,411 kg) in 1996 (Todd 1999). Information was not available for this period for the other four states with commercial fisheries—Arkansas, Indiana, Kentucky, and Mississippi. More recent catch information from these states is provided in Section IV.

There are several possible explanations for the decline in reported catch levels during the 1990s. A decline in the number of paddlefish is one explanation, and some states that permit commercial fishing have taken increasingly stringent regulatory steps over the past decade to conserve paddlefish stocks. However, it might also be the case that the regulations and restrictions themselves explain the lower numbers, as states have reduced the number of waters where commercial fishing is allowed, reduced fishing seasons, imposed legal size limits on harvestable fish, and imposed restrictions on gear size and type. In some states, for example Tennessee, there are fewer commercial fishermen today than were active in past decades, which implies that the drop in catch might be attributable at least in part to fewer boats and reduced catch effort (TRAFFIC interviews with Tennessee commercial fishermen, 2001). It is also possible that the new regulations and restrictions provide an incentive for commercial fishermen to under-report their actual catch. Finally, natural population fluctuations or environmental conditions affecting water levels (e.g., flooding, drought) likely play a role in annual catch numbers.

Ensuring that catch levels are sustainable presents a challenge to state and federal fisheries managers and commercial fishermen alike. Along with contemporary catch statistics, the relationship between regulatory regimes and reported catch is further detailed in Section IV.

Conservation Status and Challenges/Threats

IUCN's Red List 2000 classifies the North American paddlefish as Vulnerable, as assessed in 1996 (IUCN 2001). In addition, the paddlefish was listed in Appendix II of CITES in 1992, primarily because of concern about illegal catch for the international caviar trade (Graham 1997). In June 1997, the European Union listed the paddlefish in Annex B (CITES 2001a).

The species is not listed as threatened or endangered under U.S. federal law. In 1989, USFWS was petitioned to include paddlefish on the list of threatened or endangered species under the provisions of the ESA, but after conducting a review, the agency determined that listing of paddlefish as threatened was not warranted. However, because of uncertainty about the species' status in parts of its range, USFWS recommended reclassifying the species from category 3C to category 2 under the ESA. Category 3C includes taxa that have proven more abundant or widespread than previously believed and/or those that are not subject to any identifiable threat. Category 2 includes taxa for which information indicates that a proposed listing as threatened or endangered is possibly appropriate, but for which conclusive data are not currently available (Graham 1997).

Paddlefish conservation faces several primary challenges.

Habitat degradation/restricted range. Man-made changes to the Mississippi River drainage comprise the most obvious factors affecting the species' abundance and distribution from historical times to the present. Sparrowe (1986) noted that the range of the paddlefish includes some of the largest and most economically important river systems in North America. River systems such as the Mississippi, Missouri, and Ohio have long supplied much of the United States with water for commercial, industrial, and municipal uses.

Dams constructed on mainstem streams during the last century have interrupted natural spawning migrations, eliminated traditional spawning sites, altered the natural riverine hydrograph, and dewatered streams, eliminating quiet backwaters important as nursery and feeding areas (Sparrowe 1986; Graham 1997; Graham and Rasmussen 1999). As noted above, paddlefish require a specific range in water temperature and minimum flow velocity to trigger spawning (Russell 1986; Hochleithner and Gessner 1999). They are therefore sensitive to disruption or alteration of spawning habitat. The large-scale damming and channelization projects conducted over the last century to modify, or "tame," many rivers for commercial navigation, hydropower projects, and construction of water supply reservoirs have largely altered the ecology of many of the rivers inhabited by paddlefish, cutting off spawning grounds and disrupting sedimentation transport mechanisms and river

hydrographs (Sparrowe 1986; Unkenholz 1986; Rasmussen 1999).

Reservoir construction has created specific problems for paddlefish populations in some cases. Sparrowe (1986) noted that paddlefish are often associated with reservoirs rather than rivers, largely because significant fisheries have developed in reservoirs throughout the species' range. Reservoirs can benefit paddlefish populations within them by expanding and improving feeding areas. In some places fisheries have boomed temporarily following dam closure as spawning runs have congregated in the tailwaters below the dam. However, some of these fisheries later declined drastically because of lack of recruitment, as loss of spawning habitat; blocked migration routes; altered water flow regimes, hydrology, and water quality; and direct kills through operations of hydropower facilities impacted paddlefish populations (Sparrowe 1986; Unkenholz 1986).

In addition, Sparrowe (1986) noted that agricultural development has contributed to dramatic changes in many rivers and associated paddlefish habitat. Mismanagement of soil resources and reduction of erosion control efforts in the 1960s and 1970s contributed to soil movement and deposition, degrading many rivers. These factors also contributed to increased contamination of rivers by fertilizers and pesticides.

Pollution/water quality. Pollution poses another serious threat to paddlefish populations. The use of rivers as waste disposal systems, erosion, and draining of naturally cleansing wetlands and floodplains for agricultural and other purposes all affect the ecological integrity of rivers. The alteration of many rivers in the Mississippi River drainage for "slackwater" navigation has led to toxic spills, sedimentation, and dumping from dredging operations that impact paddlefish reproduction and survival (Rasmussen 1999). Watershed development and industrial pollution have at times been severe in the Ohio River and other Mississippi River tributaries, as has the problem of municipal waste (Sparrowe 1986).

The extent of river pollution and its types and sources (i.e., agriculture, pesticides, industry, urban development, sewage, etc.) obviously vary from state to state and from river to river, and are impossible to catalogue in a publication of this scope. Suffice it to say that maintaining water quality at a level that can support paddlefish, their essential habitats, and reproduction remains a challenge throughout the species' range.

Overfishing. Another potential threat to paddlefish populations comes from overfishing by commercial or sport fishermen, as well as poaching for the caviar trade. There is an ongoing debate about the severity of the threat posed by commercial catch to paddlefish populations, and it is difficult to document whether there has been a real impact on paddlefish populations from the industry and the caviar trade, given a lack of catch and catch-independent data from recent years in several jurisdictions.

A particular long-term concern to many conservationists, fisheries managers, biologists, and others is the prospect of widespread commercial harvest and trade of paddlefish roe to supply the caviar industry, in light of the dissolution of the Soviet Union and the increasing potential for the collapse of sturgeon stocks and fisheries in the Caspian Sea. TRAFFIC has noted that, should the trade turn to the North American paddlefish as an alternative—and there is evidence this is already occurring—harvest of paddlefish eggs for caviar could significantly impact what some biologists consider an already imperiled species. One example cited by Graham and Rasmussen (1999) was a 1997 CITES export permit application to export three metric tons of paddlefish roe from Kentucky to Japan for about $70 per pound ($31.50 per kg; $500,000 total). Their paper reported an estimate by biologists that to produce such an amount of roe would require the catch of nearly 1,000 females, each providing approximately seven pounds of eggs. It also included an estimate that a commercial fishermen may have to catch and sacrifice 4 to 5 males for each female with eggs (because paddlefish cannot be easily sexed, all captured fish are sometimes killed). Based on that calculation, the paper noted that catch for the permit could have involved some 5,000 to 6,000 paddlefish.

Exporting companies continue to submit applications for the export of large volumes of

paddlefish roe, none as large as three metric tons, but several greater than one metric ton (Marie Maltese, USFWS, in litt. to TRAFFIC North America, November 1, 2001). There is concern among some state fisheries managers that significantly increased paddlefish catch levels could lead to population declines similar to those seen in now threatened or endangered North American sturgeon populations.

However, there are others, particularly in the commercial fishing community, who argue that paddlefish populations are abundant. In a 2001 trip to Tennessee, TRAFFIC met with several members of the commercial fishing community involved in the catch of paddlefish. As is detailed in Section IV of this report, many in this community believe that the current threat to paddlefish is overblown, and that catch restrictions and regulations are overly stringent (TRAFFIC interviews with Tennessee commercial fishermen, 2001). Given the sometimes polar opposites in opinion over the potential threat posed to paddlefish by overexploitation, TRAFFIC believes that consensus on sustainable management will likely prove elusive.

Poaching/illegal trade. When egg prices are high, paddlefish range states commonly report occurrences of illegal catch and trade, and enforcement of paddlefish catch limitations becomes more difficult (Graham and Rasmussen 1999). Illegal trade is believed to occur in states throughout the species range, rather than just in those states that allow commercial catch. Poaching and illegal trade targets the species during its most vulnerable life stage—spawning—and takes advantage of aggregating behavior that allows for the easy take of numerous gravid females at specific, known locations.

Responding to a request for information from USFWS for a CITES Significant Trade Review regarding the species,[2] several states provided examples from recent years of paddlefish being poached for roe. Additionally, in one particularly significant case involving fraudulent trade, the owners of a Maryland company were sentenced to considerable jail time and fined $10.3 million for selling falsely labeled paddlefish caviar as Russian caviar. That fine was the largest ever assessed for a wildlife crime (USFWS 2001c). It is unclear at the time of this report whether such instances of substituting and mislabeling paddlefish roe as product from the Caspian Sea are isolated instances or part of a growing phenomenon. It is also difficult to quantify the precise extent of illegal activity involving catch and/or trade. However, it is clear that poaching and illegal trade could pose a threat to paddlefish populations. This issue is discussed in more detail in Section V.

[2] The Significant Trade Review process is described in Section 5.2 of this report.

3.5 Shovelnose Sturgeon *(Scaphirhynchus platorhynchus)*

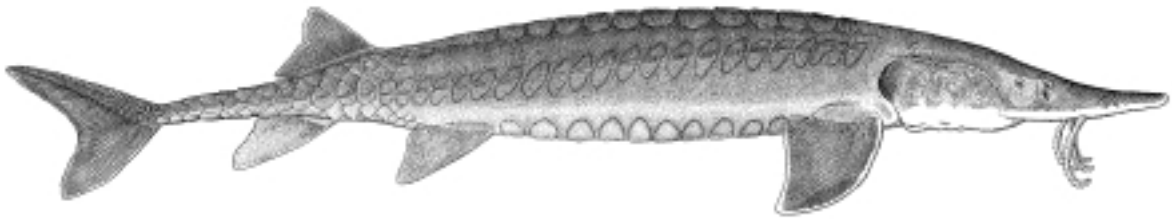


Illustration by Paul Vecsei

Also known as the sand sturgeon, hackleback, switchtail, and flathead sturgeon, the shovelnose sturgeon is a river-based species that is widely distributed in the Mississippi and Missouri river systems, as well as some larger tributaries. TRAFFIC has found that the shovelnose sturgeon, which is endemic to the United States and among the smallest of North America's Acipenseriformes, is often overlooked in debates about catch and trade for the caviar industry, even though commercial fisheries for the species exist in a number of states. Of particular concern is the lack of historic and current catch data in some states, species-specific research on population status and demographics, and adequate regulation of catch and trade in key parts of the shovelnose sturgeon's range.

Historic Range and Current Distribution

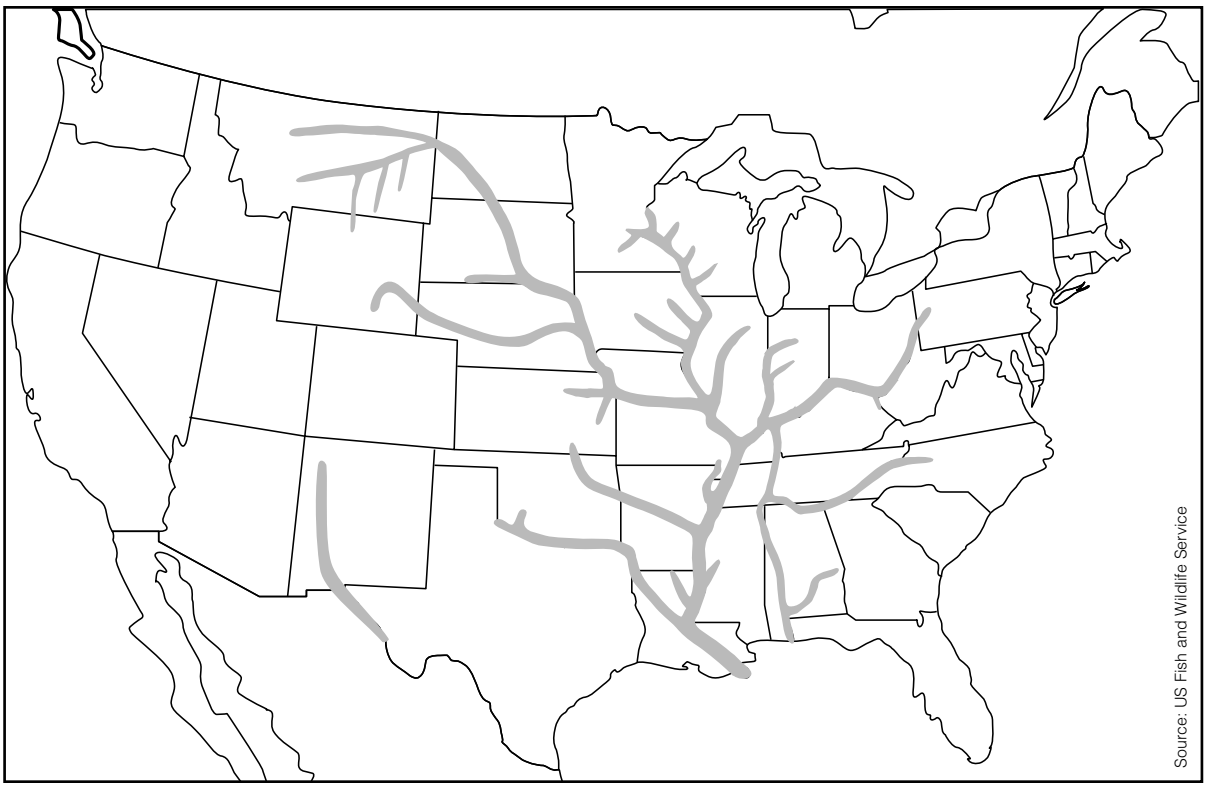
The historic range of the shovelnose sturgeon covered most of the Mississippi and Missouri river basins, from Montana in the north to Louisiana in the south, and from Pennsylvania in the east to New Mexico in the west. States that have reported historic shovelnose sturgeon populations include Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Dakota, Tennessee, Texas, West Virginia, Wisconsin, and Wyoming (Hesse and Carreiro 1997). Major river systems in the overall Mississippi-Missouri drainage system with recorded shovelnose sturgeon populations include the Yellowstone, Powder, Little Sioux, Platte, Minnesota, Chippewa, Illinois, Ohio (with Wabash), Cumberland, Nishnabotna, St. Francis, White, Arkansas, Red, and Atchafalaya (Hochleithner and Gessner 1999). Shovelnose sturgeon also historically inhabited the Mobile and Alabama river drainages in Alabama and the Rio Grande in New Mexico and Texas (Propst 1999; Rasmussen in press). Figure 5 shows the species' historic range.

Although the shovelnose sturgeon's distribution has not been reduced to the same extent as that of the lake sturgeon (*Acipenser fulvescens*) or the pallid sturgeon (*Scaphirhynchus albus*), which share portions of the shovelnose sturgeon's range, the species is no longer present in large parts of its historic range. The precise extent of range reduction—and the shovelnose sturgeon's status within its remaining range—is uncertain.

There is a general consensus that the shovelnose sturgeon is no longer extant in New Mexico, North Carolina, and Pennsylvania (NPSSC 1993; Hesse and Carreiro 1997; Keenlyne 1997; Propst 1999). Beyond agreement over the species' extirpation in those states, however, the literature differs.

Keenlyne (1997) reported the shovelnose sturgeon being classified as extirpated in Alabama, New Mexico, Pennsylvania, Tennessee, and West Virginia, as well as endangered in Ohio and Texas, rare in Mississippi, protected in North Dakota and South Dakota, and a species of concern in Louisiana, Minnesota, Oklahoma, and Wyoming. Keenlyne has noted that the species no longer reproduces from Gavins Point Dam

Figure 5 Historic Shovelnose Sturgeon Range



to Garrison Dam on the Missouri River (K. Keenlyne, *in litt*. to TRAFFIC North America, February 2002).

A Hesse and Carreiro (1997) survey of fisheries division administrators showed the species as decreasing in Alabama, Kansas, Mississippi, Ohio, and Texas; and stable in Arkansas, Indiana, Iowa, Kentucky, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wisconsin. In Georgia, Illinois, Louisiana, Minnesota, and Oklahoma, the species' status was reported as unknown, or there was no response to the survey. Hesse and Carreiro estimated that overall, the shovelnose sturgeon was absent from 25.4% of the rivers and streams that the species is believed to have historically inhabited. Andreasen (1999) used data from individual state natural heritage programs, conservation data centers, and The Nature Conservancy in recording the shovelnose sturgeon as critically imperiled in Alabama, Oklahoma, and Wyoming; imperiled in Illinois and Texas; and vulnerable in Arkansas, Indiana, and Kansas.

Some of the discrepancies in reports of the shovelnose sturgeon's status where it is extant may be attributable to differing criteria used by various agencies and data sources. Issues involving restocking programs and the presence of the species in only the peripheral waters of some states may also come into play. For example, Etnier and Starnes (1993), cited in Rasmussen (in press), reported that the shovelnose sturgeon was once commonly taken in the Tennessee River system all the way to the French Broad River on the Tennessee/North Carolina border before the Tennessee Valley Authority (TVA) reservoir system was constructed. No recent records exist of the species' presence in the Tennessee or Cumberland rivers, which would support the finding reported by Keenlyne (1997) that the shovelnose sturgeon is considered extirpated in the state. However, as is documented in Section IV of this report, in recent years Tennessee fisheries managers have recorded catch of shovelnose sturgeon in that state's portion of the Mississippi River, which constitutes its far western border with Arkansas

and Missouri (Tennessee Wildlife Resources Agency [TWRA] 2001a). Thus, while the shovelnose sturgeon may have been extirpated from internal river systems it once inhabited in Tennessee, it continues to be extant in the state's western boundary waters.

Similar issues may arise regarding the species' status in states such as West Virginia and Wyoming, which have undertaken reintroduction programs for rivers where the shovelnose sturgeon may have been extirpated (Rasmussen in press). Obrecht (1996), cited in Rasmussen (in press), Hesse and Carreiro (1997), and USFWS (2000h) reported that the species had been reintroduced into Wyoming's Bighorn and Powder rivers. The species had been extirpated from the Bighorn River Basin by dams, which blocked spawning runs from downstream in Montana [Obrecht (1996), cited in Rasmussen (in press)]. Keenlyne (1997) also noted that West Virginia and New Mexico had developed reintroduction plans. More information on these efforts is included in Section VI of this report.

Still, there appears to be a lack of reliable data regarding the shovelnose sturgeon's status in several states. As is shown later in this report, a fundamental lack of biological and demographic data about the species in river systems throughout its range has raised important questions about whether current levels of catch and trade in shovelnose sturgeon products is sustainable, and especially whether the species could withstand an anticipated increase in demand for its roe in light of the decline of the Caspian Sea fisheries.

Ecology and Habitat

The shovelnose sturgeon prefers rapid water with current velocities ranging from 0.66 to ~ 5 feet (0.2 to 1.5 meters) per second, and prefers high turbidities. The species is usually found within the rapid currents of main river channels, and favors sand and gravel substrates to feed and spawn. Shovelnose sturgeon commonly frequent the tailwaters below wing dams and other structures that accelerate current flow in channels that are otherwise impeded by man-made structures (NPSSC 1993; Hochleithner and Gessner 1999).

The shovelnose is a small sturgeon, reaching maximum lengths of 3 to 4 feet (1+ meters) and maximum weights of approximately 5 to 10 pounds (2.5 to 4.5 kg) (Hochleithner and Gessner 1999; Chapman 1999). It is estimated that sexual maturity is reached at 5 to 7 years of age, when the fish reach lengths of 20 and 24 inches (500 and 630 mm) for males and females, respectively. At this age, weights average 2 to 2.9 pounds (0.9 to 1.3 kg) (NPSSC 1993; Chapman 1999). Maximum longevity is estimated at 27 years (Chapman 1999).

Spawning normally occurs from April to July, when adults migrate upriver to spawn over rocky substrates in rapidly flowing water between 66 and 70° F (19 and 21° C). Shovelnose sturgeon eggs are glutinous, and adhere to objects in the water as they drift downstream from the spawning ground (Rasmussen in press). The spawning interval is not well known. Chapman (1999) reported a female fecundity range of between 6,000 and 17,000 eggs per kg, with egg diameters of 2.8 to 3.5 mm. Helms (1974, cited in Rasmussen in press) reported egg counts ranging from 13,908 to 51,217, with a mean average of 27,592. Christenson (1975, cited in Rasmussen in press) estimated egg production at 24,404 (ranging from 10,680 to 50,971) in Wisconsin shovelnose sturgeon from the Red Cedar–Chippewa rivers.

Food preferences of the shovelnose sturgeon consist largely of insect larvae, mussels, worms, and crustaceans, although vegetative matter is also consumed (NPSSC 1993).

Historic Fisheries/Catch Levels

Historically, in the nineteenth century shovelnose sturgeon were not commercially targeted, and were often destroyed because of damage they might cause to nets. During the early 1900s, however, targeted fisheries developed for their caviar—and meat for smoking—as other sturgeon fisheries declined (Waldman 1999). Even so, the shovelnose sturgeon was not as prized as other sturgeons or paddlefish in its range, perhaps because of its small size and correspondingly low yield of roe relative to other acipenseriform species.

Unfortunately, there is not a great deal of data available on historic take of the species. It is known that during parts of the twentieth century the species was caught in all states on the Mississippi and Missouri rivers [Helms

(1974), cited in Rasmussen (in press)], and in 1950 commercial catch accounted for 1.5% of the total catch. During the 50-year period from 1947 to 1996, the highest annual total catch of shovelnose sturgeon in states reporting catch figures from the upper Mississippi River (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) was 120,160 pounds (54,618 kg; ~54.5 metric tons) of fish taken in 1956, the lowest was 9,445 pounds (4,293 kg; ~4.3 metric tons) of fish taken in 1952, and the 50-year annual average was 21,536 kg (~23.5 metric tons) of fish [UMRCC (Annually), cited in Rasmussen (in press)]. Since installation of dams for navigation, commercial catch of shovelnose sturgeon from the Upper Mississippi River has exceeded 100,000 pounds (~45,000 kg; 45 metric tons) only twice, in 1956 and 1958 (Rasmussen in press).

Commercial fisheries in the 1980s are believed to have concentrated in several states where favorable river conditions and habitats yielded locally abundant populations. In Arkansas, for example, about 31,900 pounds (14,500 kg; 14.5 metric tons) of fish were taken from the White River in the 1980s, and in Iowa 15,400 pounds (7,000 kg; 7 metric tons) of fish were caught from the Mississippi River in 1990 (NPSSC 1993).

Eight states currently allow commercial catch of shovelnose sturgeon: Arkansas, Illinois, Indiana, Iowa, Kentucky, Missouri, Tennessee, and Wisconsin. Until very recently, however, catch data from many of these states were scarce. Todd (1999) reported an estimated 17,600 pounds (8,000 kg; 8 metric tons) of whole fish as being taken annually in Iowa. Todd (1999) also reported that the most recent 10-year average for Missouri was estimated at 17,435 pounds (7,925 kg; ~7.9 metric tons) of fish, and a 52-year mean annual commercial catch for the state was reported as 22,000 pounds (10,000 kg; 10 metric tons) of fish. Wisconsin, where eggs cannot be harvested for use in the caviar industry, estimated its annual commercial catch at 1,870 pounds (850 kg) of fish (Todd 1999). Reporting regulations have since begun to tighten because of concerns expressed by fisheries biologists. Current catch and roe harvest rates are discussed in greater detail in Section IV of this report.

As of 1999, 11 states allowed sport fishing for shovelnose sturgeon: Indiana, Iowa, Kansas, Kentucky, Minnesota, Missouri, Nebraska, Oklahoma, Tennessee, Wisconsin, and Wyoming. Little is known about approximate catch rates. The species has limited appeal and traditionally has not shown up in creel surveys (Mosher 1999).

Conservation Status and Challenges/Threats

IUCN classified the shovelnose sturgeon as Vulnerable in its 2000 Red List (IUCN, 2001). As of 2001, the proposed category for inclusion in the 2003 Red List of Threatened Species remained as Vulnerable (R. St. Pierre, IUCN/SSC Sturgeon Specialist Group, *in litt.* to IUCN/SSC Wildlife Trade Programme, November 20, 2001).

The shovelnose sturgeon was placed in CITES Appendix II in June 1997 with all other sturgeon species that were not previously listed. The listing became effective April 1, 1998 (CITES, 2001a). Decisions adopted at COP 10 with regard to the revision of CITES Appendices were published in the Official Journal of the European Communities in November 1997, to update the annexes to Regulation (EC) No. 338/97 accordingly (Caroline Raymakers, TRAFFIC Europe, in litt. to TRAFFIC North America, October 2001). A listing for the shovelnose sturgeon in the EU's Annex B entered into force on April 1, 1998, concurrent with the CITES listing (CITES 2001a). The U.S. federal government does not list the shovelnose sturgeon as threatened or endangered under the ESA. As discussed later in Section IV, some individual states classify the shovelnose sturgeon as threatened or endangered.

Conservation challenges and potential threats to the shovelnose sturgeon are similar to those for paddlefish and other sturgeon species, and include the following:

Habitat degradation/restricted range. Construction of locks and dams for navigation purposes, channelization, dredging, and other alterations in large rivers have contributed significantly to the decline of the species. These man-made habitat modifications block migration and access to spawning grounds and

eliminate habitat formerly used for spawning, feeding, and nursery grounds for juvenile fish. The species is no longer present within large portions of its former range, largely because rivers formerly inhabited by the species are now unavailable (NPSSC 1993, Hesse and Carreiro 1997).

Alterations of stream flow can also affect food availability and the species' foraging ability (Keenlyne 1997). Shortage of food may in turn delay sexual maturity or prolong the amount of time necessary to develop a full complement of eggs, which can result in unnaturally extended periods between egg production and therefore reduced population productivity (K. Keenlyne, *in litt*. to IUCN/SSC Wildlife Trade Programme, November 20, 2001).

Pollution/water quality. Pollution is also believed to pose a threat to the shovelnose sturgeon. Ruelle and Henry (1994, cited in Anon. 2002) found that both fish and eggs can accumulate elevated levels of contaminants. In the early 1990s, shovelnose sturgeon eggs from Montana had mean selenium concentrations believed to be high enough to cause reproductive failure. The concentration of organochlorines in the tissue of shovelnose sturgeon was high enough to cause the state of Missouri to issue a human health consumption advisory for Missouri and Mississippi river sturgeon eggs and flesh [Birstein (1993), cited in Anon. (1997)]. The states of Illinois, Indiana, Kansas, Kentucky, and North Dakota have also in the past issued consumption advisories for paddlefish and/or sturgeon caviar caught in certain water bodies because of PCB, chlordane (a pesticide), and mercury contamination (Caviar Emptor Online 2001).

Overfishing. In the past, pressure from commercial and recreational fishing was not considered a threat to the shovelnose sturgeon. This may be because of the greater value traditionally placed on the larger acipenseriform species found historically throughout the shovelnose sturgeon's range—primarily the lake sturgeon (*Acipenser fulvescens*) and paddlefish (*Polyodon spathula*). The small size of the shovelnose sturgeon in comparison to these other species results in relatively minor yields of roe per fish, although this roe produces an acceptable caviar (NPSSC 1993).

However, commercial fishing and poaching of shovelnose sturgeon is believed to be increasing. Much of the information is anecdotal, but for the first time, USFWS received export applications in 2000 and 2001 for large amounts of roe. As is discussed in Section IV, TRAFFIC is concerned about the increased catch pressure on the species. Current management regimes in some states may not be adequate.

3.6 Pallid Sturgeon *(Scaphirhynchus albus)*

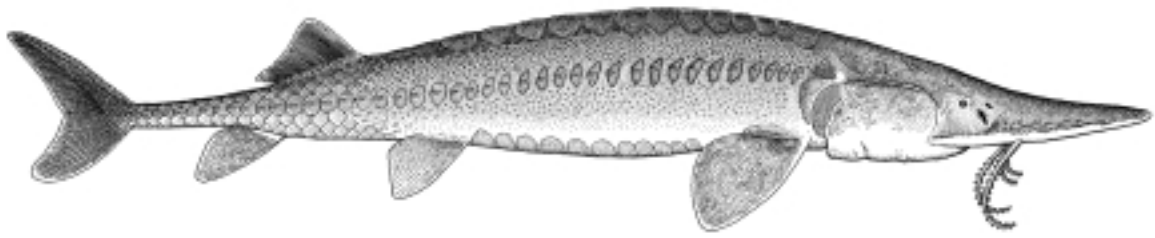


Illustration by Paul Vecsei

Endemic to the United States, the pallid sturgeon is a relatively large, freshwater fish native to the Mississippi and Missouri river basins. Also known locally as the white sturgeon (not to be confused with the Pacific coast species), white shovelnose, white hackleback, and rock sturgeon, the species shares much of its range with the shovelnose sturgeon, lake sturgeon, and paddlefish. The pallid sturgeon was listed as endangered under the ESA in 1990. Although a recovery plan is in place, the species continues to face threats from habitat modification, lack of natural reproduction, incidental catch, and hybridization. The pallid sturgeon is also the focus of a significant political battle over further modifications to its range in the upper Mississippi and Missouri rivers.

Historic Range and Current Distribution

The pallid sturgeon was first described in 1905, from specimens collected in the Mississippi River in Illinois. Historic abundance of the species is difficult to assess, but evidence suggests that it was always considered rare. In the early 1900s, pallid sturgeon were reported to comprise only one in 500 river sturgeon taken from the Mississippi River at Grafton, Illinois (NPSSC 1993).

Because of its fairly recent identification, it is difficult to accurately assess the full extent of the species' historic range. The pallid sturgeon's original distribution is believed to include the Missouri River, from Great Falls, Montana to the confluence of the Mississippi River; the middle and lower Mississippi River to the Gulf of Mexico; the Yellowstone River, from the confluence of the Bighorn River downstream to the confluence of the Missouri River; and the lower reaches of the Kansas and Platte rivers (NPSSC 1993; USFWS 2000b). Hochleithner and Gessner (1999) report that the species occurred in the Rio Grande River prior to the 1870s, and Duffy et al. (1996, cited in USFWS 2000b) stated that the historic range of the pallid sturgeon's Mississippi River range once extended upstream to Keokuk, Iowa, before the river was converted into a series of locks and dams for commercial navigation.

The current distribution of the pallid sturgeon includes the Missouri River and the Mississippi River, downstream from the Missouri River. In its 1990 final rule determining endangered status for the pallid sturgeon under the ESA, USFWS reported sightings from the mouth of the Mississippi River to the mouth of the Missouri River (1,154 river miles/1,860 river km); from the mouth of the Missouri River to Fort Benton, Montana (2,065 river miles/3,330 river km); and in the lower 200 miles (320 km) of the Yellowstone River. USFWS (1990) also noted that occasional sightings were reported from near the mouths of large tributaries of the Mississippi River, such as the Big Sunflower and St. Francis rivers, and from major tributaries of the Missouri River, such as the Kansas and Platte rivers. NPSSC (1993) reported pallid sturgeon occurrences in the Atchafalaya and Red rivers in Louisiana.

More recent information suggests that pallid sturgeon are primarily found in a few, select areas. Since 1980, the most frequent occurrences in the Missouri River system have been reported between the Marais River and Ft. Peck Reservoir in Montana; between Ft. Peck

Dam and Lake Sakakawea near Williston, North Dakota; within the lower 70 miles (113 km) of the Yellowstone River downstream of Fallon, Montana; in the headwaters of Lake Sharpe in South Dakota; near the mouth of the Platte River near Plattsmouth, Nebraska; and below river mile 218 to the Missouri River mouth in Missouri. In the Mississippi River, areas of most frequent occurrence have been reported as near Chester, Illinois, and Caruthersville, Missouri, and in the Atchafalaya River in Louisiana at the Old River Control Structure, where the Atchafalaya diverges from the Mississippi River (USFWS 2000b).

USFWS lists states within or bordering the historic and current range of the pallid sturgeon as Arkansas, Iowa, Illinois, Kansas, Kentucky, Louisiana, Missouri, Mississippi, Montana, Nebraska, North Dakota, South Dakota, and Tennessee. The total extent of the pallid sturgeon's range has been estimated at approximately 3,500 river miles (5,635 river km) (USFWS 1990, 2000b, 2001d). Figure 6 shows the likely historic range of the pallid sturgeon.

Ecology and Habitat

The pallid sturgeon is believed to reach lengths of six feet (1.8 meters) (Hochleithner and Gessner 1999). Estimates of maximum weights cited for the species vary. USFWS (1990) described a maximum weight of close to 85 pounds (39 kg). Hochleithner and Gessner (1999) estimated approximately 100 pounds (45 kg); Chapman (1999) estimated 66 to 100 pounds (30 to 45 kg). It is widely believed that hybridization occurs naturally between pallid and shovelnose sturgeons (USFWS 1990, 2000b; NPSSC 1993; Hochleithner and Gessner 1999).

Figure 6 Historic Pallid Sturgeon Range

Source: US Fish and Wildlife Service (revised)

Until recently, little had been documented about the life history requirements of the pallid sturgeon. The species is known to prefer turbid, free-flowing river habitats, and to favor stretches with rapid currents, swifter than those preferred by the shovelnose sturgeon (USFWS 1990, 2000b; NPSSC 1993; Hochleithener and Gessner 1999). The species is most frequently caught over a sand bottom, and is believed to prefer sandy substrates, particularly sand dunes. In some areas the species has also been found over substrates of rock or gravel. Pallid sturgeon are believed to be more specific and restrictive in the use of microhabitat selection than are shovelnose sturgeon, indicating that features in these microhabitats may be more important to pallid sturgeon. Bramblett (1996, cited in USFWS 2000b) found that these microhabitats were diverse and dynamic. For example, pallid sturgeon were found to use river reaches with sinuous channel patterns and islands and alluvial bars, which generally have more diversity of depths, current velocities, and substrates than do relatively straight channels without islands or alluvial bars. However, USFWS (2000b) noted that caution must be exercised in evaluating habitat preference studies conducted in highly altered river environments, because there is no way to measure pallid sturgeon preferences for habitats that no longer exist.

Spawning is believed to occur between March and July, depending on location (USFWS 2000b). Because existing data indicate that extremely limited natural reproduction is occurring in wild populations, little information is available to delineate precise spawning areas. Chapman (1999) reported that pallid sturgeon reach sexual maturity at 5 to 20 years of age. USFWS (2000b) cited Keenlyne and Jenkins (1993) in estimating sexual maturity for males at 7 to 9 years of age, with 2- to 3-year intervals between spawning years, and female sexual maturity at 15 to 20 years of age, with 3- to 10-year intervals between spawning years. Chapman (1999) estimated that females have a fecundity of approximately 10,000 eggs per kg of body weight, and that pallid sturgeon eggs have a diameter of 2.5 to 3.1 millimeters.

Little is known about age or growth of pallid sturgeon. Chapman (1999) estimated the maximum age of the species at 39–41 years. However, a female pallid sturgeon aged following mortality in 1998 was estimated to be more than 50 years old, and possibly as high as 60 (USFWS 2000b).

Food sources of the pallid sturgeon have been reported to include benthic macroinvertebrates, as well as lake and terrestrial invertebrates, which suggests that drifting invertebrates may be important foraging organisms. Adult pallid sturgeon are believed to consume a greater proportion of fish than do shovelnose sturgeon (USFWS 2000b).

Historic Catch

Estimating historic catch rates for the pallid sturgeon is virtually impossible. Waldman (1999) reported that pallid sturgeon and lake sturgeon were sought after for roe during the nineteenth century, while the smaller shovelnose sturgeon were often discarded as bycatch. The combined catch for lake sturgeon, pallid sturgeon, and shovelnose sturgeon was as high as 429,990 pounds (195,450 kg) in the early 1890s, but declined to less than 20,020 pounds (9,100 kg) by the 1950s (Waldman 1999; USFWS 2000b). Given that the pallid sturgeon is believed to have been historically rare, it is likely that the significant majority of those figures document catch of lake sturgeon and shovelnose sturgeon.

Conservation Status and Challenges/Threats

IUCN listed the pallid sturgeon as Endangered on its 2000 Red List of species (IUCN 2001). Pallid sturgeon were listed in Appendix II of CITES at COP 10 in June 1997, along with all previously unlisted sturgeon species; the listing entered into effect in April 1998. Decisions adopted at COP 10 with regard to the revision of CITES Appendices were published in the Official Journal of the European Communities in November 1997, to update the annexes to Regulation (EC) No. 338/97 accordingly (Caroline Raymakers, TRAFFIC Europe, *in litt*. to TRAFFIC North America, October 2001). A listing for the pallid sturgeon in EU Annex B entered into effect on April 1, 1998, concurrent with the CITES listing (CITES 2001a).

As is discussed in greater detail in Section IV, the pallid sturgeon was listed as a federally endangered species under the ESA in 1990; a

recovery plan was published in 1993 (USFWS 1990, 1993). The species faces continuing threats from several sources.

Habitat degradation/restricted range. The decline of the pallid sturgeon followed extensive development of the Missouri and Mississippi rivers during the twentieth century. Factors cited by USFWS in its 1990 Final Rule determining endangered status for the species included physical blocking of natural movements and migrations because of construction of large dams; alteration of water quality, temperature, and flow, affecting reproduction, timing of reproduction, and availability of food sources; alteration and removal of historic spawning habitats; decreased habitat diversity; and an overall reduction of biological productivity throughout the river basins.

USFWS (1993, 2000b) noted that on the mainstem of the Missouri River, approximately 36 percent of riverine habitat within the pallid sturgeon's range was transformed from river to lake by construction of six massive earthen dams by the Army Corps of Engineers between 1926 and 1952. Another 40 percent of the river downstream from dams has been channelized, and the remaining 24 percent of river habitat has been altered by changes in water temperature and flow caused by dam operations. In the lower Mississippi River, levee construction from the Ohio River to the Gulf of Mexico has eliminated the river's major natural floodway and reduced the area of the floodplain connected to the river by more than 90 percent (USFWS 2000b).

These habitat changes were reflected in a sharp drop-off of pallid sturgeon observations from the 1960s to the 1980s. During the 1960s, 500 total observations (approximately 50 per year) were made in the entire 3,550 miles of range. Observations dropped to 209 (about 21 per year) during the 1970s, and there were only 65 observations (about 7 per year) during the 1980s (USFWS 1990). The forage base for the pallid sturgeon has likely been greatly altered, thus affecting growth, reproduction, and recruitment (NPSSC 1993).

As is discussed in greater detail in Section IV, in both the Upper Mississippi and Missouri rivers, the Army Corps of Engineers has worked with USFWS to try to mitigate the impact of ongoing Corps projects on the pallid sturgeon. Such efforts face the significant challenge of simultaneously enhancing conservation prospects for the pallid sturgeon (and other endangered species) while maintaining the navigation projects and activities that are believed to have contributed to the species' decline. Commercial shipping and barge operations, agricultural interests, and other commercial ventures have a large stake in maintaining both the Mississippi and Missouri rivers as transit "highways" for farm products and other goods, and there is strong opposition to efforts to restore the rivers to more natural flows. Whether the Corps' conservation and mitigation projects and activities in these river sections will prove successful remains unclear. The pallid sturgeon's situation is a prime example of the tension that often accompanies efforts to conserve endangered species when the restoration activities conflict with human economic activity.

Rarity/lack of natural reproduction. Corresponding to the loss and degradation of pallid sturgeon habitat, there has been an apparent loss of natural reproduction of the species. Remaining riverine habitat between dams, especially in the Missouri River from Gavins Point Dam to the headwaters, apparently does not meet spawning requirements of the species because successful reproduction has not been documented. It is unlikely that any natural reproduction occurred on the upper Missouri River for many years because, as of 1988, the youngest pallid sturgeon captured in the region was 10 years old. However, in October 1992, the Louisiana Department of Wildlife and Fisheries captured two young pallid sturgeon, believed to be less than three years old, while monitoring commercial catch of other species below the Old River Control Structure at the headwaters of the Atchafalaya River swamp (NPSSC 1993). The first reported capture of a young-of-the-year pallid sturgeon did not occur in the Mississippi River until 1998, and in 1998 and 1999 a total of three larval pallid sturgeon were collected in the Missouri River (USFWS 1999, 2000i). Thus, spawning populations of the species may still be present in some areas of its range, but there is scant contemporary evidence of the extent of such activity.

Overfishing. There is currently no legal commercial or recreational take of pallid sturgeon. However, a period of observed decline for the species in the 1950s and 1960s coincided with an increase in commercial catch of sturgeon species (USFWS 1990). Commercial harvest of paddlefish continues in seven states within the range of the pallid sturgeon, and commercial harvest of shovelnose sturgeon is allowed in eight states, which increases the potential for incidental take. Sport fishing for both paddlefish and shovelnose sturgeon is also permitted in a number of pallid sturgeon range states, and mortality of pallid sturgeon as a result of illegal and incidental harvest from both commercial and sport fishing was documented during the 1990s in Illinois, Louisiana, Nebraska, and South Dakota. The pallid sturgeon may also be affected by the illegal take of eggs for the caviar trade (USFWS 2000b).

Pollution/water quality. Pollution is believed to be an exacerbating threat to the pallid sturgeon in much of its range. Pollution of the Missouri River by organic wastes from towns, packing houses, and stockyards was evident by the early 1900s, and increased as populations grew and industries were added along the river. In the Mississippi River, the presence of a variety of pollutants prompted numerous fish-harvest and consumption advisories during the 1980s and 1990s from Kansas City, Missouri, to the river's mouth, which represents approximately 45 percent of the pallid sturgeon's range. In addition, PCBs, cadmium, mercury, and selenium were detected at elevated levels in pallid sturgeon collected from the Missouri River in North Dakota and Nebraska, as were detectable concentrations of DDE, DDT, and dieldrin (USFWS 2000b). Further investigation is needed to assess the role of such contaminants in the decline of pallid sturgeon populations.

Hybridization. In recent years, studies have increased the body of knowledge regarding the genetic, morphologic, and habitat differences between the pallid sturgeon and shovelnose sturgeon. Whereas it has been hypothesized that pallid sturgeon and shovelnose sturgeon are reproductively isolated in less altered habitats such as the upper Missouri River, and research has found substantial differences in habitat use and movements between adult pallid sturgeon and shovelnose sturgeon in less altered habitats of the Yellowstone River, it has been speculated that the loss of habitat diversity caused by man-made alterations of river systems in the two species' ranges has inhibited naturally occurring reproductive isolating mechanisms. As a result, natural hybridization, backcrossing, and genetic introgression between pallid sturgeon and shovelnose sturgeon may be reducing the genetic divergence between the two species (USFWS 2000b). A study by Keenlyne et al. (1994, cited in USFWS 2000b) concluded that hybridization may be occurring in half the river reaches within the range of the pallid sturgeon, that hybrids may represent a high proportion of remaining sturgeon stocks, and that there are indications that the hybrids are fertile and reproducing. Such hybridization could pose a threat to the survival of pallid sturgeon through genetic swamping as the species continues to introgress with the shovelnose sturgeon, as well as through competition for limited remaining habitat [Carlson et al. (1985); Sheehan et al. (1997), both cited in USFWS (2000b)].

3.7 Alabama Sturgeon *(Scaphirhynchus suttkusi)*

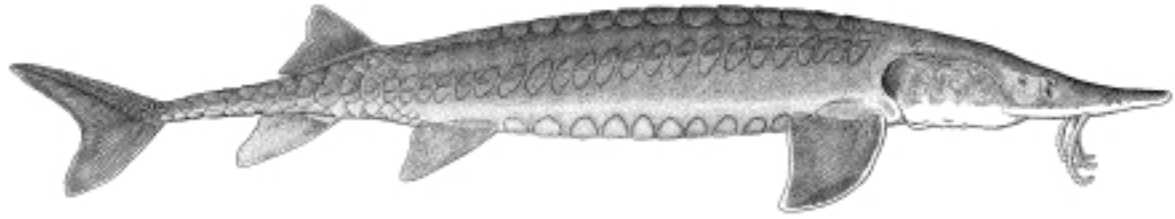


Illustration by Paul Vecsei

The Alabama sturgeon, also known as the Alabama shovelnose, hackleback, buglemouth trout, and devilfish, is a small, endangered sturgeon species endemic to the United States. The species was once familiar to commercial fishermen; however, it is now so rare that the species' future survival is in doubt. Alabama sturgeon are presently found in only one small stretch of river in Alabama. Listed as endangered under the ESA in 2000, recovery efforts for the species are underway.

Historic Range and Current Distribution

The Alabama sturgeon is believed to have once inhabited as much as 1,000 miles (1,600 km) of the Mobile River system in Alabama and Mississippi. Within this system, there is evidence that the species was historically present in the Black Warrior, Tombigbee, Alabama, Coosa, Tallapoosa, Mobile, Tensaw, and Cahaba rivers in Alabama, as well as parts of the Tombigbee River in Mississippi (Anon. 1999a; USFWS 2000c).

Historical catch reports indicate that the Alabama sturgeon was once relatively common throughout all of these major coastal plain tributaries of the Mobile River system. The species apparently existed in sufficient numbers to support a commercial fishery at the end of the nineteenth century. Unfortunately, unregulated catch and habitat alterations are believed to be key contributing factors leading to significant declines in Alabama sturgeon abundance and reduction of range over the past century. The Alabama sturgeon is believed to have disappeared from about 85 percent of its historic range, including the upper Tombigbee, lower Black Warrior, lower Tallapoosa, and upper Cahaba rivers, where the species was last reported in the 1960s. The last known reports of Alabama sturgeon in the lower Coosa River were around 1970, and in the lower Tombigbee River around 1975. The last known report of the species in the lower Cahaba River came in 1985. There is a single record from 1985 of an Alabama sturgeon caught in the Mobile-Tensaw River delta, but there have been no reported incidental catches since that time (Anon 2000b; USFWS 2000c).

Since 1985, all confirmed captures of Alabama sturgeon have come from a short (130 mile), free-flowing section of the Alabama River below Millers Ferry and Claiborne Locks and Dams in Clarke, Monroe, and Wilcox counties, Alabama. This is the species' only known present distribution (Anon 2000b; USFWS 2000c). Figure 7 shows the current range of the Alabama sturgeon.

Ecology and Habitat

There is little available information on the life history characteristics, habitat, or ecological requirements of the Alabama sturgeon. In part, this is because the species was only recently described as a species separate from the shovelnose sturgeon. While the first specimens in museum collections date from about 1880, the first mention of the fish in the scientific literature did not come until 1955, well after the species' decline had begun, and substantial alterations to historic habitat further contributing to its decline had occurred. Reference to the Alabama sturgeon as the Alabama shovelnose sturgeon came in 1976, and in 1991 the species was formally described based on a statistical comparison of relative sizes and features of morphological structures

Figure 7 Current Alabama Sturgeon Range

of Alabama and shovelnose sturgeons. While not discussed in detail here, some controversy continues about whether the Alabama sturgeon is truly a separate species from the shovelnose sturgeon (USFWS 2000c).

The Alabama sturgeon is a small, freshwater sturgeon that reaches about 31 inches (80 cm) in length and weighs 2 to 4 pounds (~1 to 2 kg) at maturity. It is believed to prefer low-velocity currents and sandy or stable gravel substrates in flowing river channels. Verified captures have primarily occurred in large channels of big rivers, although at least two historic records involved Alabama sturgeon found in oxbow lakes (Anon 2000b; USFWS 2000c). Other aspects of Alabama sturgeon life history have been deduced by reviews of the spawning habits and other characteristics of the closely related shovelnose sturgeon (Mayden and Kuhajda 1996; Keenlyne 1997). These data suggest that Alabama sturgeon likely migrate upstream during late winter and spring to spawn, and migrate downstream to feeding areas in deeper, cooler waters during the summer (Hochleithner and Gessner 1999; USFWS 2000c).

Alabama sturgeon are believed to reach sexual maturity at 5 to 7 years of age, and the species may live up to 15 years or more. Spawning frequency is likely influenced by food supply availability, but could occur every one to three years. Eggs are probably deposited on hard bottom substrates such as bedrock, armored gravel, or channel training work in deep water habitats, and possibly in tributaries to major rivers. The eggs require current for proper development and adhere to the substrate. When the eggs hatch, the larvae become part of the river plankton, and likely drift with the currents. Post-larval stages have been reported to disperse to the river bottom. Following yolk absorption, juvenile sturgeon are believed to

begin feeding on minute planktonic crustaceans, but soon become bottom feeders and dwellers (Anon. 2000b; USFWS 2000c).

The Alabama sturgeon's primary food sources are thought to include insect larvae, supplemented by molluscs, fish, and fish roe. Organic debris and plants found in stomach content samples provide evidence that the species is an opportunistic bottom feeder (Hochleithner and Gessner 1999; Anon. 2000b; USFWS 2000c).

Historic Catch

Although some records exist of a substantial commercial catch of Alabama sturgeon during the late nineteenth century, the intermittent frequency of reporting does not allow for an accurate analysis of the fishery prior to collapse. In an 1898 report to Congress, the total commercial catch of shovelnose sturgeon in Alabama was reported as 42,000 pounds (19,000 kg). Of this, 39,800 pounds (18,000 kg) came from the Alabama River, and 2,200 pounds (1,000 kg) came from the Black Warrior River (USFWS 2000c). Waldman (1999) cites a review by Mayden and Kuhajda (1996) to point out that this 19,000 kg of "shovelnose sturgeon" may have represented approximately 19,000 individuals given the average weight of the fish. USFWS (2000c) placed the figure at possibly 20,000 fish. The location of that commercial catch may indicate that the species discussed was the Alabama sturgeon, even though the species had not yet been taxonomically identified as such. However, it is impossible to deduce from available information whether the catch included only Alabama sturgeon, shovelnose sturgeon, or a mixture of the two, and if so in what percentages.

After the 1898 report, there are few records of commercial catch of Alabama sturgeon. A 1930 article in the Alabama Game and Fish News (cited in USFWS 2000c) reported that the species was not uncommon, but there were no records of commercial catch. Despite the lack of catch records, it is believed that commercial fisheries may have continued to affect the species. Keenlyne (1997) noted that early in the twentieth century, commercial fishermen considered shovelnose sturgeon a "nuisance" or "trash" fish, and destroyed them when they were found in their nets. Interviews with commercial and recreational fishermen indicated that Alabama sturgeon continued to be taken from the Alabama River into the 1980s (USFWS 2000c). All commercial and recreational fishing for the Alabama sturgeon is currently prohibited.

Conservation Status and Challenges/Threats

Today, the Alabama sturgeon is one of the rarest fishes in North America (Anon. 1999a). The IUCN 2000 Red List designated the Alabama sturgeon as Critically Endangered (IUCN 2001). That designation is consistent with the findings of USFWS and others that the Alabama sturgeon continues to face threats to its survival from its reduced range, small population numbers, and a lack of information detailing its habitat and life history requirements that complicates recovery efforts.

The species was placed in CITES Appendix II at COP 10 in June 1997 with all other previously unlisted sturgeon species; the listing entered into effect in April 1998 (Gnam 1999; CITES 2001a). Decisions adopted at COP 10 with regard to the revision of CITES Appendices were published in the Official Journal of the European Communities in November 1997, to update the annexes to Regulation (EC) No. 338/97 accordingly (Caroline Raymakers, TRAFFIC Europe, in litt. to TRAFFIC North America, October 2001). A listing for the Alabama sturgeon in EU Annex B entered into effect on April 1, 1998 concurrent with the CITES listing (CITES 2001a).

In May 2000, USFWS published a Final Rule listing the Alabama sturgeon as an endangered species, bringing it under the protection of the ESA (Anon. 2000b; USFWS 2000c). The history of the listing decision is described in greater detail in Section IV.

There are several historical reasons that help to explain the decline of the Alabama sturgeon, as well as several continuing threats to the species' survival.

Overfishing. It is believed that the historic population decline of the Alabama sturgeon was initiated by unrestricted catch near the turn of the century. As was described above, similar to other sturgeon fisheries, the fishery

for the Alabama sturgeon initially yielded high catch levels, followed by a rapid decline. The demise of the sturgeon fishery in the Mobile River Basin befell both the Alabama and Gulf sturgeons (NPSSC 1993; Anon. 2000b; USFWS 2000c). Neither species has significantly rebounded in the basin, despite continuing bans on any catch.

Habitat degradation/restricted range. In the Final Rule listing the Alabama sturgeon as an endangered species, USFWS noted that the Alabama sturgeon has lost much of its habitat over the past century. Navigation-related development of the Mobile River Basin significantly altered extensive portions of river channel habitats, blocked long-distance movements, hindered or halted migrations, and fragmented and isolated sturgeon population segments. It is believed that the Alabama sturgeon is currently present in no more than 15% of its historic range (Anon. 2000b; USFWS 2000c).

More than 30 locks and/or dams now control the major rivers of the Mobile River Basin, forming a series of lakes with short, free-flowing sections between them. Within the historic range of the Alabama sturgeon, there are three dams on the Alabama River, two on the Black Warrior River, and six on the Tombigbee River. These dams, built between 1954 and 1979, fragment some 583 miles (933 km) of riverine channel habitat essential to the Alabama sturgeon. The species' habitat requirements cannot be met in impoundments, where weak flows result in heavy siltation, making the impoundment bottom unsuitable for spawning and larval and post-larval survival and development. Impoundments may also negatively affect the bottom-dwelling invertebrates the sturgeon feed upon (Anon. 2000b; USFWS 2000c).

Prior to the widespread construction of dams in the Mobile River basin, Alabama sturgeon could move freely between feeding areas, and from feeding areas to sites that favored spawning and development of eggs and larvae (Anon. 2000b). Dams are now believed to block the movement of Alabama sturgeon between these critical habitats, as well as preventing them from reaching thermal refugia during hot summer months. Fragmented by these obstacles, the species may have formed isolated population segments, and dams may also preclude recolonization of suitable habitat. Furthermore, isolated population segments can be more vulnerable to local declines in water and habitat quality caused by poor land management practices, as well as pollution (Anon 2000b; USFWS 2000c).

Along with significant construction of dams and locks during the past 50 years, most of the major rivers in the Alabama sturgeon's historic range have been dredged or channelized to improve navigation. Some rivers are routinely dredged to maintain appropriate navigation depths when they begin to fill naturally through sediment deposition. In comparison to natural stretches of river, dredged and channelized sections have reduced habitat diversity through the loss of shoals, removal of snags, elimination of bendways, reduction in flow heterogeneity, and other factors. Channel dredging and the destruction of shoals, shallow runs, and other feeding and spawning sites likely has contributed to declines in the range and abundance of the Alabama sturgeon. Many of these biologically disruptive activities are ongoing (Anon. 2000b; USFWS 2000c).

Dams built for navigational purposes or power production also affect the amount and timing of water moving through the Mobile River Basin. To facilitate navigation, water depths are controlled through discharges from upstream dams; hydroelectric power production also changes flow velocities. These factors alter the natural cycle and flow of affected rivers, impacting migratory activity, spawning, and other features of the sturgeon's life cycle (Anon. 2000b; USFWS 2000c).

Unfortunately, the lack of knowledge of the life history and habitat needs of the Alabama sturgeon makes it difficult to assess the impacts of these various habitat alterations on remnant population fragments and to develop recovery strategies. It is not currently known whether the quantity of habitat remaining in the lower Alabama River is adequate to meet the species' life history needs, nor is there definitive evidence regarding the potential impact of continuing human activities such as maintenance dredging of navigation channels, and whether it may threaten the Alabama sturgeon's existence (Anon. 2000b).

Rarity/lack of natural reproduction. The Alabama sturgeon's low numbers and apparent inability to offset mortality rates with current reproduction rates is believed to pose a grave threat to the species. Although there are no population estimates for the Alabama sturgeon, steadily diminishing incidents of capture over the past several decades indicate declining population numbers over that time. Recent collection efforts have demonstrated its rarity. Between the spring of 1997 and the year 2000, up to four crews of professional fisheries biologists expended more than 4,000 man hours of fishing effort in the lower Alabama River to capture Alabama sturgeon for use as broodstock as part of a voluntary conservation plan. This effort resulted in the capture of only four Alabama sturgeon. Commercial and recreational fishermen on the river were also interviewed and asked to report any sturgeon captures to the Alabama Department of Conservation and Natural Resources (ADCNR). Only two incidental captures were reported, one of which was delivered to the ADCNR. Three years of intensive fishing effort thus resulted in the capture of only five Alabama sturgeon, suggesting that the species is extremely rare, and the collection history indicates that the species is likely in continuing decline. The situation raises concerns that there is a lack of sufficient recruitment to offset mortality. Lack of knowledge about the life history and ecological requirements of the species compound this threat by making it difficult to devise appropriate recovery strategies (Anon. 2000b).

3.8 Lake Sturgeon *(Acipenser fulvescens)*

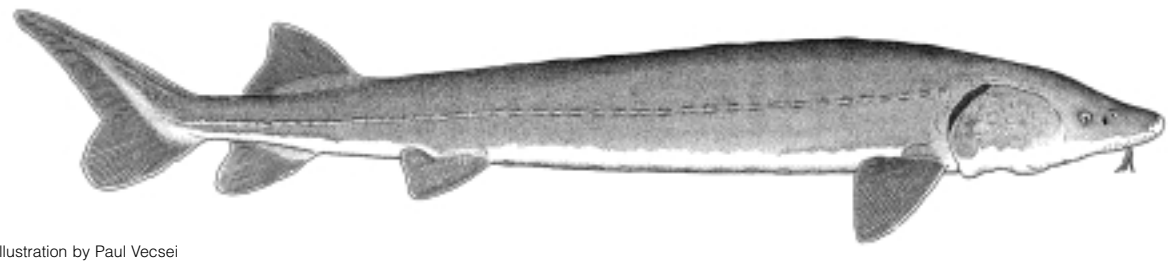


Illustration by Paul Vecsei

The lake sturgeon was once widely distributed, found in much of southern Canada and the eastern half of the United States, from the Great Lakes to the Mississippi Delta. Also sometimes referred to as the rock sturgeon or rubbernose sturgeon, the species has been either extirpated or nearly so from large areas of its historic range, particularly in the United States. Whereas abundant lake sturgeon populations once supported important commercial fisheries in both the United States and Canada, commercial fishing is now prohibited throughout the species' U.S. range, and only limited sport and/or Native American fisheries are allowed in a few states. In Canada, limited commercial fishing continues in Ontario and Quebec.

Historic Range and Current Distribution

Historically, the lake sturgeon was abundant in three major watersheds: the Great Lakes, the Mississippi River drainage, and the Hudson-James Bay drainage (NPSSC 1993). The species remains relatively widespread in Canada, but its range has been significantly reduced within the United States. Figure 8 shows the current distribution of the lake sturgeon.

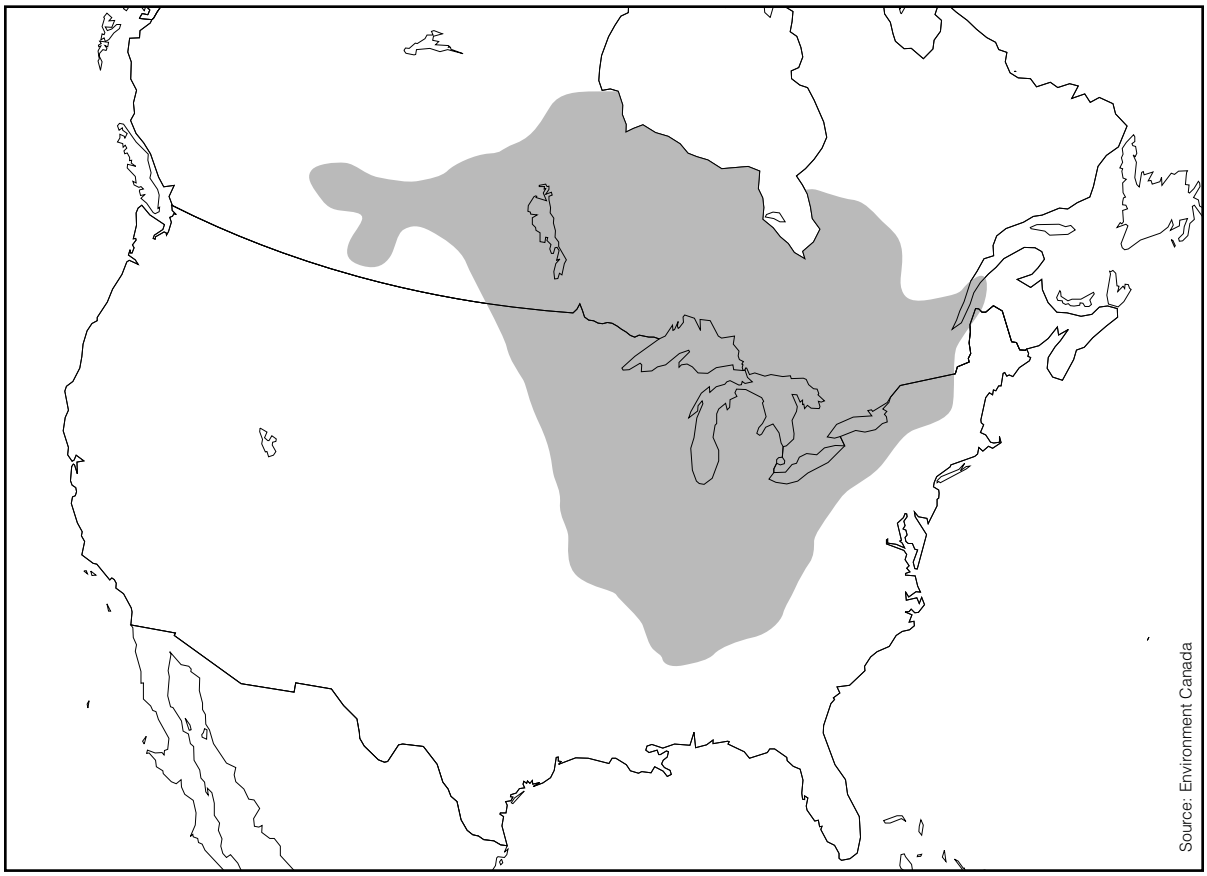
In Canada, the lake sturgeon's historic distribution included rivers and lakes in the provinces of Alberta, Saskatchewan, Manitoba, Ontario, and Quebec. It was found as far west as Edmonton on the North Saskatchewan River, as far east as St. Roch de Aulinaires on the St. Lawrence River, as far north as the Seal River, and as far south as Lake Erie (Houston 1987; Ferguson and Duckworth 1997; Hochleither and Gessner 1999).

In the United States, the species' historic range extended from the Great Lakes in the north, to the Missouri River in the west, to Vermont and New York's Lake Champlain in the east, and to the mouth of the Mississippi Delta in the south (Hochleither and Gessner 1999). Hesse and Carreiro (1997) listed states with historic lake sturgeon populations as including Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New York, Ohio, Pennsylvania, Tennessee, Vermont, West Virginia, and Wisconsin. Survey data in Hesse and Carreiro also indicate that the species may have been present in Georgia, Louisiana, North Carolina, North Dakota, and South Dakota, but the species' historic status in those states is uncertain.

The lake sturgeon's current distribution is more limited. In Canada, lake sturgeon continue to occur in larger rivers and lakes from the North and South Saskatchewan rivers in the west to the St. Lawrence River in the east, and from the Great Lakes in the south to Hudson Bay in the north. However, some populations in Canadian waters have been greatly reduced or extirpated over the course of the past century, in particular in Lakes Winnipeg, Ontario, and Erie (Houston 1987; Ferguson and Duckworth 1997).

Lake sturgeon in the United States are today found primarily in the northern portion of their U.S. range. Wisconsin, which has had an active lake sturgeon management program for nearly 100 years, likely has the most abundant U.S.

Figure 8 Current Lake Sturgeon Range



population, with the largest segment in the Winnebago System (Bruch 1999). Other states in the region where lake sturgeon populations were once believed to be abundant now report significantly reduced populations. For example, Michigan's lake sturgeon population was estimated in 1997 to be approximately 1% of its historic size (Hay-Chmielewski and Whelan 1997). Lake sturgeon populations also continue to exist in Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, New York, Ohio, Pennsylvania, and Vermont. However, as is documented in more detail in Section IV, lake sturgeon currently appear on the threatened or endangered species lists of several of these states in its northern and mid-Mississippi River range.

The lake sturgeon is believed to be entirely or nearly extirpated from most of the mid-southern to southern Mississippi River drainage portion of its former range. Alabama, Arkansas, Georgia, and North Carolina presume the species is extirpated within their waters (Hesse and Carreiro 1997; Stan Cook, Chief of Fisheries, ADCNR, in litt. to Teiko Saito, USFWS/OMA, August 15, 2000; April Layher, Biologist, Fisheries Division, Arkansas Game and Fish Commission, *in litt*. to Teiko Saito, USFWS/OMA, August 18, 2000; Richard M. Gennings, Chief of Fisheries, Georgia Department of Natural Resources Wildlife Resources Division, in litt. to Teiko Saito, USFWS/OMA, August 21, 2000). Hesse and Carreiro (1997) reported the species as extirpated in Kentucky; however, it is possible that fragmentary natural populations may still exist there and in Tennessee, where the species is listed as endangered (Robb Todd, Commercial Fishing Coordinator, Tennessee Wildlife Resources Agency, in litt. to Teiko Saito, USFWS/OMA, August 21, 2000). There are no recent reports of lake sturgeon presence in the Mississippi Delta, where the lake sturgeon's presence was probably never

extensive (Hesse and Carreiro 1997; USFWS, *in litt*. to TRAFFIC Europe, September 2000).

Ecology and Habitat

Lake sturgeon are normally confined to freshwater, notwithstanding historic reports of their occasional presence in brackish regions of the St. Lawrence River and Moose River in Canada (NPSSC 1993). The lake sturgeon is a large and long-lived fish; several reports indicate maximum lengths over 7 feet (2.4 meters), weights reaching as much as 300 pounds (140 kg), and one individual determined to be 152 years of age (NPSSC 1993; Chapman 1999; Hochleithner and Gessner 1999). More typically, lake sturgeon are believed to reach 4 to 5 feet in length (~1.5 meters), 60 to 70 pounds in weight (~30 kg), and 40 years of age (Hochleithner and Gessner 1999).

The preferred habitat of the lake sturgeon is shallow riverine and lacustrine waters with a rocky or muddy substrate; the species is commonly found in the highly productive shoals of large lakes and rivers. Overwintering takes place in deep, oxygen-rich sections of water in large rivers or lakes. After spring snowmelt, the fish travel to smaller rivers in mixed groups of various ages and sizes. During spring migration, which can cover several hundred miles, the fish do not feed (Hochleithner and Gessner 1999).

Lake sturgeon are believed to reach sexual maturity between 12 and 22 years of age in males, and 14 to 27 years of age in females. Male lake sturgeon spawning interval has been reported as 2 to 3 years, while females are believed to spawn every 4 to 6 years. Tagging programs reveal that individual fish often migrate to the same spawning grounds year after year, and subsequently return to the same foraging grounds for the winter. Spawning season depends upon the geographical range of the population, and lasts from April to June in most areas. The temperature required to initiate spawning has been recorded as 53 to 66° F (12–19° C). Spawning takes place in groups of two to three females, accompanied by one to two males, over rocky or pebble substrate (Hochleithner and Gessner 1999).

Fecundity rates are reported to approach 10,000 to 13,000 eggs per kg of female body weight. Egg size averages 2.5 to 3 mm in diameter. Development of fertilized eggs takes 5–7 days at 59–63° F (15–17° C). Newly hatched larvae are about 8 mm long, and begin to consume exogenous food after 10–14 days, after they attain a size of about 21 mm (Chapman 1999; Hochleithner and Gessner 1999). Young age classes inhabit areas with a detectable current and flat substrate composed of small gravel and coarse sand. They are believed to be a solitary species, remaining close to the substrate and spatially oriented upstream (Hochleithner and Gessner 1999). Lake sturgeon grow very slowly in the wild. It is believed that four or five years are usually required to reach a length of 20 inches (51 cm) and a weight of 1.1 pounds 0.5 kg (NPSSC 1993).

Lake sturgeon feed primarily on benthic invertebrates such as insect larvae, oligochaetes, bivalve mollusks, snails, and crustaceans. Small fish are also opportunistically consumed (Hochleithner and Gessner 1999).

Historic Catch

The lake sturgeon has long been an important commercially and recreationally fished species. Accounts from the nineteenth century, however, indicate that this was not always the case. Scott and Crossman (1973, cited in Waldman 1999) reported that the lake sturgeon was once looked upon by fishermen as a worthless nuisance that destroyed gear set for other, more valuable species. Captured lake sturgeon were slaughtered and either piled on shore to be dried and then burned, fed to pigs, or used as fertilizer or fuel in steamboats on the Detroit River. Roe was used as hog feed or fish bait.

The negative perception of the lake sturgeon began to change around the middle of the century, and by 1860 lake sturgeon were caught for meat (fresh and smoked), eggs for caviar, skins for leather, and swim bladders for isinglass (Waldman 1999). In 1860, a sturgeon processing plant was built in Sandusky, Ohio that began marketing smoked sturgeon on a large scale [Harkness and Dymond (1961), cited in Anon. (2000c)]. The industry grew quickly; perhaps the most intense period of fishing began around 1885 in both the United States and Canada, when annual catches in Lake Erie reached 5 million pounds (2.25

million kg) (Waldman 1999). Lake sturgeon fisheries also developed rapidly on Lakes Huron, Ontario, Superior, Nipissing, and Nipigon, with fisheries in the western part of the species' range maturing later than eastern ones [Ferguson and Duckworth (1997), cited in Waldman (1999)].

As with other sturgeon species, these intense catch levels and overexploitation led to a rapid collapse of the fishery. Annual catch on Lake Erie declined by as much as 80% by 1895. In Ontario's Lake of the Woods, landings declined by 90% between 1893 and 1900 (Waldman 1999). In Lake Huron, commercial landings exceeded 996,000 pounds (453,000 kg) in 1885, but declined by 56% between 1893 and 1900 [Harkness and Dymond (1961), cited in Anon. (2000c)]. The catch from Lake Winnipeg and its tributaries peaked at 445 tons in 1890, but like its eastern counterparts did not last long, and was reduced to a mere 13 tons by 1910, when the fishery was closed (Waldman 1999).

Today, catch of lake sturgeon continues, but at greatly reduced levels. Commercial catch is prohibited in U.S. waters. Minnesota, Michigan, and Wisconsin continue to allow limited sport catches, but the present focus of most U.S. management efforts is on recovery and restoration. In Canada, only Ontario and Quebec currently allow commercial fishing. The only commercial fishery allowed in the Great Lakes region is in the Ontario portion of Lake Huron. Sport fishing is either banned or closely regulated in the provinces of Alberta, Manitoba, Ontario, Quebec, and Saskatchewan. Details regarding catch of lake sturgeon in various jurisdictions are provided in Section IV.

Conservation Status and Challenges/Threats

IUCN classifies the lake sturgeon as Vulnerable (IUCN 2001). The species was placed in CITES Appendix II at COP 10 in June 1997 with all other previously unlisted sturgeon species; the listing entered into effect in April 1998 (CITES 2001a). Decisions adopted at COP 10 with regard to the revision of CITES Appendices were published in the Official Journal of the European Communities in November 1997, to update the annexes to Regulation (EC) No. 338/97 accordingly (Caroline Raymakers, TRAFFIC Europe, *in litt*. to TRAFFIC North America, October 2001). A listing for the white sturgeon in EU Annex B entered into effect on April 1, 1998 concurrent with the CITES listing (CITES 2001a). The lake sturgeon is not federally protected in either the United States or Canada. As seen in Section IV, however, it is listed as an endangered, threatened, or protected species in several U.S. states.

Threats to the lake sturgeon are similar to those faced by other acipensiform species in the Mississippi River Basin.

Overfishing. As with other North American sturgeon species, the history of the lake sturgeon fishery demonstrates that the balance between conservation and catch is fragile, and overexploitation can rapidly lead to steep population declines. Although Canada's commercial catch of the species is regulated today, and the primary demand has been for meat, the increasing demand for roe for the caviar trade could reverse progress if not monitored carefully. This developing demand is particularly noteworthy because it has been reported that the roe of the lake sturgeon produces the finest caviar of any North American species [Scott and Crossman (1973), cited in Waldman (1999)].

On a positive note, there is growing evidence that lake sturgeon populations can recover if sufficient numbers of adult fish and adequate, appropriate habitat are maintained. For example, the population in Wisconsin's Lake Winnebago system was stable during the 1930s and 1940s, but increased after property owners began stabilizing riverbanks to reduce erosion, thus increasing the amount of habitat suitable for spawning (NPSSC 1993). Wisconsin has also developed a fairly large and successful sport fishery for the species over the past few decades (Bruch 1999). State and provincial fisheries agencies face a delicate task in balancing commercial and recreational interest in lake sturgeon against the continuing need for strong conservation measures to promote the species' recovery and allow populations to rebuild.

Habitat degradation/restricted range. Dam construction, channelization, dredging, and other human activities that destroy or degrade sturgeon habitat pose significant management challenges (NPSSC 1993; Houston 1997;

Ferguson and Duckworth 1997). As the example of the Lake Winnebago system demonstrates, lake sturgeon populations can recover if they have access to suitable spawning and feeding grounds (NPSSC 1993; Bruch 1999). The fact that the species is now considered extremely rare or extirpated in many parts of its historic range, particularly in river systems in the southeastern United States, can be attributed largely to widespread damming and other alterations in support of navigation and commerce in the Mississippi and Missouri river systems. Maintaining sufficient suitable habitat and spawning grounds as development continues in these areas presents a difficult challenge involving numerous public and private entities.

Pollution/water quality. Pollution from industrial sources, toxic spills, urban development, sewage, erosion, and draining and alteration of wetlands for agricultural use all affect lake sturgeon habitat. This is true in the species' riverine and lacustrine habitats in both the United States and Canada. Point source pollution varies from system to system, but one important indicator of its effects and the management challenges that it poses is the health advisories issued by many local areas limiting or banning the consumption of paddlefish, sturgeon, and other fish species in certain waters (Caviar Emptor Online 2001). Like other Acipenseriformes, the lake sturgeon's life history characteristics and feeding behavior may leave the species particularly vulnerable to bio-accumulation of organochloride compounds.

3.9 White Sturgeon *(Acipenser transmontanus)*

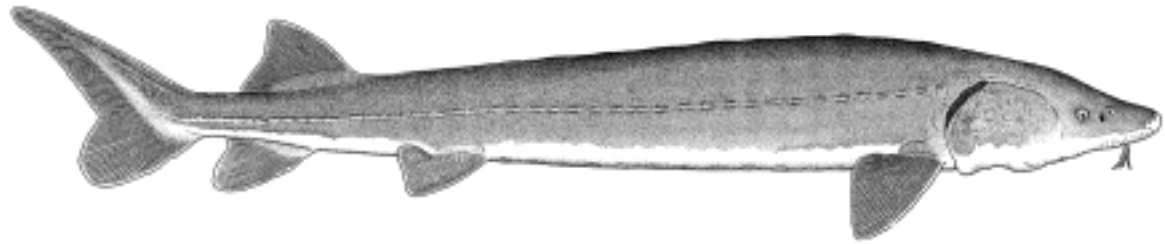


Illustration by Paul Vecsei

Native to major rivers and nearshore waters along the Pacific coast of the United States and Canada, the white sturgeon is the largest acipenseriform species occurring in North America. Also known as the Pacific Sturgeon, Sacramento Sturgeon, Oregon Sturgeon, and Columbia Sturgeon, the white sturgeon can be found as far inland as Idaho and Montana. Highly valued, the white sturgeon is both commercially fished and prized as a sport fish. While white sturgeon populations remain relatively abundant in some portions of their historic range, the species is believed to have been extirpated from blocked areas in the Columbia and Snake rivers, and a number of other landlocked populations are at risk. There is also a federally listed, endangered sub-population—the Kootenai River white sturgeon. White sturgeon are commercially farmed to support a caviar and meat industry, with the industry centered in California.

Historic Range and Current Distribution

The historic distribution of the white sturgeon included coastal waters and major river systems along much of the Pacific coast, from Mexico to Alaska. Today, the historic distribution remains fairly intact. It is believed that the species may occur in Pacific coastal waters (to a depth of 100 feet) as far north and west as Alaska's Aleutian Islands and as far south as Ensanada, Mexico, in Baja California. However, known spawning populations currently exist in only a few major river systems between the Sacramento–San Joaquin rivers in California and the Fraser River in British Columbia. Smaller, non-spawning populations may be found in other riverine and coastal systems from California to Alaska (Oregon Department of Fish and Wildlife [ODFW] 1995a; Pacific States Marine Fisheries Commission [PSMFC] 1996a; B.C. Fisheries 2001a). Figure 9 shows the overall range of the white sturgeon.

Locations of some of the most important spawning populations of white sturgeon, and smaller non-spawning populations, are described below.

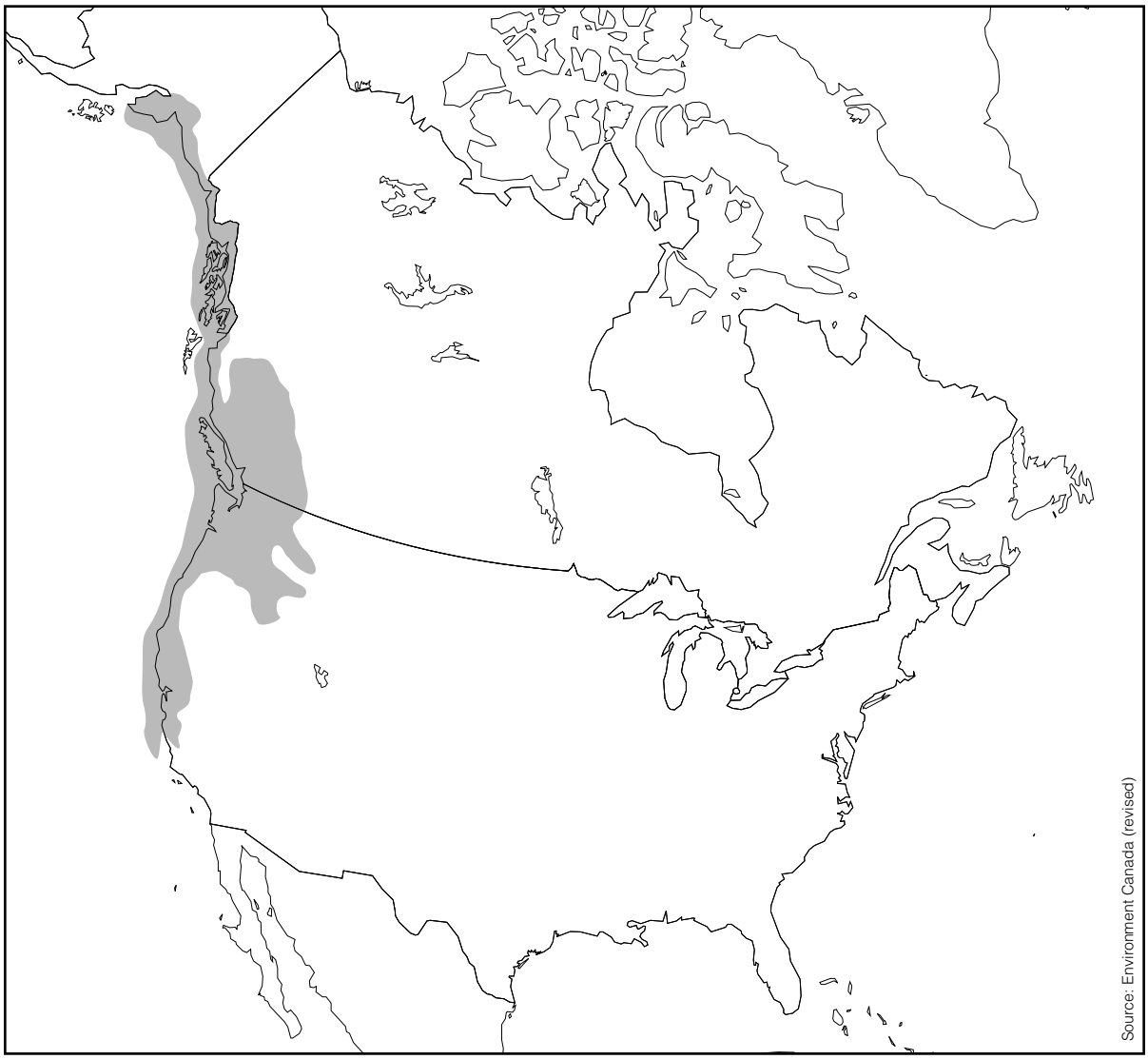
Canada

Canada's white sturgeon population occurs only in British Columbia. Within the province, spawning populations are believed to have concentrated historically in three river systems: the Fraser/Nechako, Columbia, and Kootenay rivers.

Fraser/Nechako rivers. Canada's Fraser River is a nonregulated river that originates in the Rocky Mountains near Jasper and follows a winding course for some 825 miles (1,375 km) before emptying into the Strait of Georgia near Vancouver. The river and its tributaries drain a major portion of British Columbia. In 1995, British Columbia initiated a five-year assessment program to gather biological and stock status information on white sturgeon that would assist management and conservation efforts in the Fraser River system (RL&L Environmental Services 2000a).

Among the findings of the study, which was funded by the Habitat Conservation and Trust Fund, Forest Renewal BC, and Fisheries Renewal BC, was an indication that there are at least five putative stocks of white sturgeon

Figure 9 White Sturgeon Range



in the Fraser River watershed. One stock, the Lower Fraser Mainstem population, was identified in the lower Fraser River between Mission, at river mile 47 (river km 78), and Bristol Island at river mile 92 (river km 153). The second identified stock was the Lower Fraser Canyon population, located primarily in three main areas of the Lower Canyon section of the lower Fraser River from approximately river mile 92.5 (river km 154) to river mile 126.5 (river km 211). White sturgeon concentrations in this river segment stretch from the vicinity of Hope, including the confluence area of the Coquihalla River at river mile 95.4 (river km 159), to between Alexandra Bridge and Blackwater Canyon downstream of Hell's Gate at river miles 120 to 125 (river km 200 to 208). The third identified stock was the Middle Fraser population, whose boundaries were demarcated from river mile 127 (river km 212) to river mile 474 (river km 790). White sturgeon in this population were broadly distributed between Boston Bar, at river mile 132 (river km 220), and Prince George at river mile 474 (river km 790). The fourth identified stock inhabits the upper Fraser River above Prince George, where white sturgeon were most commonly found near the confluence of major tributaries (RL&L Environmental Services 2000a).

The fifth identified stock consists of white sturgeon populations in the Nechako River and its tributaries, most notably the Stuart River (RL&L Environmental Services 2000a). The Nechako River flows into the mainstem Fraser River from the west in the vicinity of Prince George, and its white sturgeon population has been found to be distinct from other Fraser River populations. Movement studies using conventional tag-recapture techniques and radio-telemetry suggest that fish from this population do not migrate to the Fraser River. It is believed that the unique Nechako River population is at greater risk than other Fraser River stocks. Specifically, the Nechako River stock is dominated by larger and older fish than those of other stocks. Most Nechako River white sturgeon are more than 30 years old, suggesting that the population suffers from either poor spawning success or high juvenile mortality (RL&L Environmental Services 2001a).

Overall, the 1995–1999 British Columbia assessment program found that white sturgeon density was highest in the lower sections of the Fraser River, with population abundance generally declining as the geographic range of the stock group became more northerly. Population estimates published in the study included 17,259 sturgeon in the Lower Fraser Mainstem stock, with a density of 368.2 fish per mile (230.1 fish/km); 976 sturgeon in the Lower Fraser Canyon stock, with a density of 27.4 fish per mile (17.1 fish/km); 3,745 sturgeon in the Middle Fraser stock, with a density of 10.4 fish per mile (6.5 fish/km); and 571 sturgeon in the Nechako River stock, with a density of 2.4 fish per mile (1.5 fish/km). Data were not collected to determine the population size and distribution of white sturgeon in the tidal zone of the lower Fraser River below Mission. Estimates were also not made for the Upper Fraser stock group because of insufficient data collected. However, the information that was collected suggests that the area is mainly used by juveniles and sub-adults, and that densities are low (RL&L Environmental Services 2000a).

It is believed that the northern populations exhibit a slower growth rate and consequently reach sexual maturity later than do the southern stocks. The study noted that localized movements were common for all of the stocks, although larger-scale movements were observed for feeding, overwintering, and spawning. Evidence of white sturgeon movements from the middle to lower Fraser River through Hell's Gate suggested genetic mixing between these stocks (RL&L Environmental Services 2000a).

Columbia/Kootenay rivers. Two additional distinct white sturgeon populations are found in the upper Columbia and Kootenay rivers in British Columbia. Historically, white sturgeon were likely to be distributed within the mainstems of both of these rivers in Canada, as well as in the larger tributaries and lakes within their drainages. At one time, these populations had access to the Pacific Ocean, although it is likely that resident sub-populations were also present. However, the last glaciation approximately 10,000 years ago formed a natural barrier at Bonnington Falls on the lower Kootenay River, effectively isolating white sturgeon in Kootenay Lake and the Kootenay River from Columbia River populations (RL&L Environmental Services 2000b).

Canada's Kootenay white sturgeon population is contiguous with the United States' Kootenai River population, and is discussed below in more detail (see Box 2 on Kootenai River White Sturgeon). In the British Columbia portion of the Columbia River system, dam construction has resulted in additional fragmentation and isolation of white sturgeon populations. Three dams have been constructed since the ratification of the Columbia River Treaty between Canada and the United States in 1968. Two of the dams, Hugh L. Keenleyside Dam (HLK) and Mica Dam, ensure that adequate storage is available to provide the hydro-generation potential and flood control required by the treaty. Revelstoke Dam, a non-treaty dam, was constructed by BC Power for hydroelectric power generation (RL&L Environmental Services 2000b, 2001b).

HLK Dam, a flow regulation facility commissioned in 1968, is the furthest downstream of the dams, and is located at the south end of Arrow Reservoir in British Columbia. The Columbia River downstream from HLK Dam to Lake Roosevelt is one of the few remaining free-flowing sections of the Columbia River. This area supports a small population of white sturgeon that is considered highly threatened by recruitment failures likely

related to the effects of river regulation and industrial development (RL&L Environmental Services 2000b, 2001b).

There may also be remnant white sturgeon populations trapped behind or between dams on the Columbia River in British Columbia, and in larger lakes and tributaries within this system. For example, reconnaissance surveys in 1995 and 1997 recorded the presence of a possible remnant white sturgeon population in Arrow Reservoir, between HLK and Revelstoke dams. Studies conducted in 1999 confirmed a white sturgeon spawning area below Revelstoke Dam. The only other known spawning area in the Columbia River in Canada is located below HLK Dam at the confluence of the Pend d'Oreille and Columbia rivers (RL&L Environmental Services 2000b, 2001b). As is detailed more fully in Section IV, the critically imperiled status of Canada's remnant populations in both the Columbia and Kootenay rivers has led management authorities to undertake special conservation measures.

Other systems. Outside of these river systems, white sturgeon have been observed in the mouth of the Cowichan and Somass rivers on Vancouver Island; however, it is believed that these are migratory fish from the mainland systems, rather than separate spawning populations (B.C. Fisheries 2001a).

United States

Anadromous populations of white sturgeon are believed to spawn only in the Columbia, Rogue, Sacramento-San Joaquin, and possibly Klamath river systems in the United States. Resident freshwater populations are also present in portions of the Columbia River Basin, including the Kootenai and Snake rivers (ODFW 1995a).

The Columbia River Basin. The Columbia River Basin system spans seven U.S. states as well as the portion of British Columbia described above, and contains several white sturgeon populations. At one time, virtually all of this population had access to the Pacific Ocean, and may have used both freshwater and saltwater habitats. However, a series of major hydroelectric, flood control, irrigation water storage, navigation, and diversion projects, beginning downstream with the Bonneville Dam, have effectively segmented the Columbia River Basin population into three groups: the lower Columbia River below the lowest dam, with access to the ocean; fish isolated (functionally but not genetically) between dams; and fish in several large tributaries (Miller et al. 2001). As is described in Box 2 below, one sub-population—the Kootenai River population of white sturgeon—is genetically distinct from other Columbia River Basin populations.

The Columbia River constitutes a significant portion of the boundary between Oregon and Washington, and the two states manage white sturgeon populations cooperatively in these waters. The largest, most productive white sturgeon population in all of the species' current range is located within the 145 river miles (233 river km) of the lower Columbia River downstream from Bonneville Dam (DeVore et al. 1999). As is discussed in more detail in Section IV, stock estimates of legally harvestable fish between 1989 and 2000 ranged from a low of 38,100 in 1990 to a high of 202,200 in 1995. Lower stock estimates in 1999 and 2000 have prompted fisheries agencies to consider more restrictive catch limits and other conservation measures (Joint Columbia River Management Staff [JCRMS] 2001a). However, according to DeVore et al. (1999), it appeared that the decline of stocks evident between 1995 and 1997 was not a result of excessive catch in the lower Columbia River, but was rather attributable to a decrease in recruitment to the legal-sized population and a mass emigration from the Columbia River system.

Upstream from Bonneville Dam, mainstem Columbia and Snake river dams, which are largely impassable to white sturgeon, have effectively isolated inland populations in reservoir pools and river stretches between impoundments. While historic population structure in the overall Columbia River Basin system is unknown, and seasonal migration barriers may have occurred on the mainstem rivers, it is likely that gene flow occurred because over their lifetimes individuals probably moved throughout the Columbia and Snake rivers. Today such freedom of movement is made impossible by the dams, and individual population fragments may not contain gene pools that are representative of the larger historical populations. For example, impassable

dams have isolated inland white sturgeon into resident population segments in areas between upstream impoundments, including Bonneville Pool, The Dalles Pool (Lake Celilo), the John Day Pool (Lake Umatilla), McNary Pool (Lake Wallula), the mainstem Snake River below Hells Canyon Dam, Hells Canyon Pool, Oxbow Pool, and Brownlee Pool. Reproductive success is believed to be low in many of these populations, and is not believed to occur in Hells Canyon Pool or Oxbow Pool (ODFW 1995a).

The Snake River has 12 dams from its mouth upstream to Shoshone Falls in Idaho. Many of the populations in Snake River segments have been extirpated, or consist only of a few trapped adults without significant juvenile recruitment. White sturgeon are believed to exist in small numbers in the lower three pools formed by Ice Harbor, Lower Monumental, and Little Goose dams. The species appears to be more abundant in regions where free-flowing river habitat exists, such as between Lower Granite Dam and Hells Canyon Dam, where some 75% of the river is free-flowing (Miller et al. 2001). In the upper reaches of the Snake River in Idaho, white sturgeon are extant, as they also are in the Salmon River. However, these populations are considered significantly depleted (Idaho Department of Fish and Game [IDFG] 2000). Life history models are being prepared to determine the risk of extinction for white sturgeon populations between Shoshone Falls and Lower Granite Dam on the middle Snake River (H. Jaeger, Oak Ridge National Laboratory, in litt. to TRAFFIC International, December 10, 2001). Research is also ongoing to describe the genetic structure of white sturgeon populations within the Columbia River Basin (T. A. Rien, Oregon Department of Fish and Wildlife, *in litt*. to IUCN/SSC Wildlife Trade Programme, October 31, 2001).

Sacramento-San Joaquin rivers. The Sacramento-San Joaquin River Basin drains about 59,000 square miles (153,000 km2) of California's Central Valley, and contains a reproducing population of white sturgeon, primarily located in the larger Sacramento River as far upstream as Shasta Dam. White sturgeon are also believed to spawn in the San Joaquin River (Kohlhorst et al. 1991), and the species may also use the Feather River as a spawning ground (Anon. 2001b). The confluence of the Sacramento and San Joaquin rivers forms a large tidal estuary containing a network of more than 683 miles (1,100 km) of tidal sloughs and channels. White sturgeon inhabit the estuary year-round, including San Francisco, San Pablo, and Suisin bays and the Sacramento-San Joaquin Delta (Anon. 2001b).

Other systems. White sturgeon are believed to spawn in Oregon's Rogue River basin and are present in the mainstem up to Savage Rapids Dam, and in the Illinois River up to Illinois Falls. White sturgeon are also believed to spawn in the Willamette River in Oregon, a tributary of the Columbia River. Along the Oregon coast, white sturgeon are found in numerous estuaries, including the Nehalem River and Bay, Tillamook Basin, Nestucca River and Bay, Siletz River and Bay, Yaquina River and Bay, Alsea River and Bay, Suislaw River and Bay, Umpqua Basin, Coos River Basin, Coquille River Basin, and Chetco River and Bay. These aggregations are not considered spawning populations; white sturgeon in these estuaries are believed to originate from populations in the Fraser, Columbia, Rogue, and Sacramento-San Joaquin systems (ODFW 1995a). White sturgeon are also believed to be present in bays, estuaries, and the nearshore ocean along the Washington coast including Gray's Harbor, Willapa Bay, the Straits of Juan De Fuca, and the San Juan Islands. However, white sturgeon are believed to be rare in Puget Sound and the Hood Canal (PSMFC 1996a; WDFW 2001a). White sturgeon are also known to enter or inhabit the Klamath/Trinity River Basin, but it is uncertain whether this is a spawning population (ODFW 1995a). The Klamath River is not thought to sustain a stable white sturgeon population (M. Parsley, US Geological Survey, *in litt*. to IUCN/SSC Wildlife Trade Programme, October 18, 2001).

Ecology and Habitat

The white sturgeon is not only the largest North American sturgeon species, but also the largest freshwater fish in North America, reaching lengths of close to 20 feet (>6 meters) and weights approaching 2,000 pounds (>900 kg). It is also a very long-lived fish species; Chapman (1999) estimated white sturgeon longevity at greater than 82 years. One female caught in Oregon in 1991 was aged at 104

years. Most fish caught in recent times, however, have been much smaller and younger (NPSSC 1993; Hochleithner and Gessner 1999).

Sexual maturity is estimated to range from 10 to 20 years in males, and 15 to 30 years in females. The male spawning interval is believed to be one to two years, while females spawn every two to six years (Hochleithner and Gessner 1999). NPSSC (1993) reported that spawning occurs between March and June when water temperatures reach between 50 and 63° F (10–17° C). Spawning in the Columbia River has been reported as occurring between April and July (M. Parsley, US Geological Survey, *in litt*. to IUCN/SSC Wildlife Trade Programme, October 18, 2001). Since 1993,

Box 2. Kootenai River White Sturgeon*

The officially termed and listed "Kootenai River population of white sturgeon" was listed as endangered throughout its range in the United States and Canada on September 6, 1994. This population is restricted to approximately 168 miles (270 kilometers) of the Kootenai River in Idaho and Montana, and Kootenay Lake in British Columbia, primarily upstream from Cora Linn Dam at the lake's outflow. While the population is able to migrate freely from Kootenai Falls in Montana downstream to Kootenay Lake, a natural barrier at Bonnington Falls downstream of Kootenay Lake has isolated the Kootenai River white sturgeon from other white sturgeon populations in the Columbia River Basin since the last glacial age, approximately 10,000 years ago. Figure 10 shows the population's range.

This separation produced a genetically distinct white sturgeon sub-population. Kootenai River white sturgeon, like other landlocked populations, tend to be smaller than the anadromous fish of the lower Columbia River. The largest white sturgeon reported from the Kootenai River basin was a 350 pound (159 kg) individual, estimated at 85 to 90 years of age, captured in Kootenay Lake in 1995. While the size or age at first maturity for wild white sturgeon is variable, Kootenai system females have been documented to mature as early as age 22, and males are found to mature at age 16. Many adults are believed to spend much of their life in deep Kootenay Lake and may migrate as much as 71 miles (114 kilometers) up the Kootenai River to spawn. Other sturgeon in the population inhabit the upper river reaches.

With the exception of 1974, recruitment of the Kootenai River population of white sturgeon has decreased since the mid-1960s. Human activities have altered the natural flows of the Kootenai River, affecting the population's spawning, egg incubation, nursery, and rearing habitats, and reducing the overall productivity of the Kootenai River and Kootenay Lake. The operation of Libby Dam since 1974 is considered to be a primary cause of continuing declines. When the dam began regulating the Kootenai River, average spring peak flows were reduced by more than 50 percent, and winter flows increased by almost 300 percent. Thus, natural high spring flows necessary as a cue for reproduction now occur only rarely during the spawning season. As a result, since 1974 there has been an almost complete lack of recruitment. The population also faces threats because of reduced biological productivity, the effects of contaminants, and possibly poor water quality. By 1997, the population was estimated at approximately 1,468 wild fish, with few individuals younger than 25 years of age.

Figure 10. Kootenai River White Sturgeon Range

Continued on next page

International cooperation between the United States and Canada to protect and conserve the Kootenai River white sturgeon population began in June 1992, with the formation of the Kootenai River White Sturgeon Technical Committee. The Committee, composed of representatives from several U.S. state, tribal, federal, and Canadian agencies, was formed to identify factors affecting Kootenai River white sturgeon and develop a regional prelisting recovery strategy. After the species' listing as endangered, a recovery team composed of two Canadians and eight Americans was formed in January 1995. The team completed a final recovery plan for the Kootenai River white sturgeon in 1998, which was approved by the U.S. Fish and Wildlife Service in late 1999. Recovery objectives include the reestablishment of successful reproduction in the wild by increasing Kootenai River flows, and production of hatchery-reared juveniles over the next decade, to prevent extinction. Since 1997, the wild population has been augmented with the release of nearly 2,800 juvenile white sturgeon reared in the Kootenai Tribal Fish Hatchery in Bonner's Ferry, Idaho.

Canada continues to implement transboundary recovery actions on behalf of the Kootenai River population of white sturgeon. British Columbia Environment (BC Environment) and the Canadian Department of Fisheries and Oceans continue to actively participate in recovery implementation and coordination activities associated with regulating flows at Kootenai River hydroelectric projects to benefit Kootenai River white sturgeon. BC Environment is currently conducting white sturgeon monitoring and assessment work in Kootenay Lake. These studies are complementary to those conducted in Idaho by the Idaho Department of Fish and Game and the Kootenai Tribe of Idaho. BC Environment also recently approved the use of the Kootenay Trout Hatchery near Fort Steele, B.C., as a back-up or fail-safe white sturgeon facility. Fertilized eggs have been exported from the Kootenai Tribe Hatchery in Idaho to the Kootenay Trout Hatchery to ensure that at least some juvenile sturgeon survive for later release into the Kootenai River in the event some catastrophe occurs at one of the primary hatcheries.

Flow augmentation proposals for Libby Dam for the benefit of white sturgeon may result in water spill at some other Canadian Kootenai River dams. The United States and Canada continue to cooperate in evaluating the potential fisheries, power production, and flood control impacts from flow augmentation.

* Sources: USFWS (2000d); Duke (1999).

the first recorded annual spawning in the Columbia River has consistently occurred once mean daily water temperatures reach about 57° F (14° C), with subsequent events occurring up until peak water temperatures of 70° F (21° C) [Hildebrand et al. (1999), cited in CITES Management Authority of Canada, in litt. to TRAFFIC International, November 29, 2001]. Environmental factors such as day length, water current and habitat quality have also been cited as important spawning cues (CITES Management Authority of Canada, *in litt*. to TRAFFIC International, November 29, 2001).

Preferred spawning grounds for white sturgeon are areas of pebble and rock substrates, in deep pools, and behind ripples in swift current. White sturgeon are "broadcast" spawners. Eggs and sperm are released into rapidly flowing water, which serves to disperse the eggs and prevent them from clumping together and smothering one another, and protects the eggs from siltation which could bury them. The semi-buoyant, adhesive eggs may drift considerable distances downstream before sinking and adhering to the substrate (NPSSC 1993). Female fecundity has been estimated at 5,000 to 23,000 eggs per kg of body weight (Chapman 1999). Hochleithner and Gessner (1999) estimated an average of ~5,600/kg. Egg diameter ranges between 2.6 and 4.0 cm (Chapman 1999).

White sturgeon prefer a diet of benthic invertebrates such as crustaceans, insects, molluscs, and fish, including lamprey, smelt, anchovies, and salmonids. Juveniles feed primarily on mysid shrimp, amphipods, and molluscs (NPSSC 1993; Hochleithner and Gessner 1999). Information collected from the

Columbia River indicates that white sturgeon are opportunistic carnivores that will feed on whatever fish or invertebrates are seasonally or locally available [Hildebrand et al. (1999), cited in CITES Management Authority of Canada, in litt. to TRAFFIC International, November 29, 2001].

Historic Catch

There is historic evidence of Native American white sturgeon catch prior to European colonization, for food and use as a cultural icon. The arrival of European colonists and later incorporation of the Pacific coast region into the United States and Canada during the nineteenth century introduced major commercial fisheries that had significant impacts on white sturgeon populations (Waldman 1999).

Among the three major river systems supporting white sturgeon, the commercial fishery in the Sacramento-San Joaquin Basin lasted from the 1860s until 1901, then reopened temporarily before being closed permanently in 1917. San Francisco Bay supported the largest commercial white sturgeon catch in the basin; most fish were caught on setlines or "China" gang-lines in San Francisco Bay and the lower reaches of the Sacramento and San Joaquin rivers. The fishery reached its peak in 1885 (1.66 million pounds; 747,000 kg), dwindling to 300,000 pounds by 1895. The fishery was closed in 1901, when less than 200,000 pounds were landed. Attempts to reopen the commercial fishery occurred in 1909, 1916, and 1917, but low catch rates indicated that the population had not adequately recovered; in 1917 legislation was enacted to prohibit all sturgeon fishing. Incidental take of white sturgeon associated with other gill net fisheries continued despite the prohibition; therefore, legislation was enacted in 1957 that prohibited the use of any commercial gear that might capture white sturgeon in these fisheries. In 1954 California opened a recreational fishery for white sturgeon that continues to this day (Waldman 1999). There are no Native American ceremonial or subsistence fisheries in the Sacramento-San Joaquin River system.

The white sturgeon commercial fishing industry developed later in the Columbia River system. Waldman (1999) reported that the fishery began in the 1880s, and peaked in 1892 when 5.5 million pounds (2.5 million kg) of white sturgeon were caught, representing the equivalent of some 80,000 fish. The intense, unregulated catch led to the collapse of the lower Columbia fishery, causing fishermen to travel upriver in search of large fish, until by 1899 less than 99,880 pounds (45,400 kg) were taken in the Columbia River system. Regulations setting seasons, gear, and minimum size failed to restore the stock, and the fishery remained depressed for more than 70 years. Recovery did not begin until 1950, when broodstock were protected by the enactment of a six-foot maximum size limit designed to protect sexually mature white sturgeon (Beamesderfer 1999; Waldman 1999). Today, the lower Columbia River supports the most significant remaining white sturgeon commercial fishery. This fishery is described in greater detail in Section IV.

In Canada's Fraser River, prior to the 1880s the only catch of white sturgeon came from Native American fishermen who used them for food and trade, including trade of isinglass with the Hudson River Company until 1866. After caviar and smoked sturgeon became popular in the United States and the build-up of the Fraser River salmon fishery, the white sturgeon catch in this system peaked in 1897 at 1,137,696 pounds (511,963 kg). The fishery soon collapsed, with catch declining 20% by 1900 and 93% by 1905. The collapse of the fishery created a conflict between Native American tribes and the Canadian government, which seized nets and drained a backwater used as a primary fishing location (Waldman 1999). Commercial and recreational catch and retention of white sturgeon is currently prohibited in British Columbia.

Conservation Status and Challenges/Threats

IUCN classifies the white sturgeon as at Lower Risk (near threatened), with a separate designation for the Kootenai River population as Endangered (IUCN 2001). The species was placed in CITES Appendix II at COP 10 in June 1997 with all other previously unlisted sturgeon species. The listing entered into effect in April 1998 (CITES 2001a). Decisions adopted at

COP 10 with regard to the revision of CITES Appendices were published in the Official Journal of the European Communities in November 1997, to update the annexes to Regulation (EC) No. 338/97 accordingly (Caroline Raymakers, TRAFFIC Europe, *in litt.* to TRAFFIC North America, October 2001). A listing for the white sturgeon in the EU's Annex B entered into effect on April 1, 1998 concurrent with the CITES listing (CITES 2001a).

The white sturgeon receives no federal status designation in the United States, with the exception of the Kootenai River population, which as noted above was listed as Endangered under the ESA on September 6, 1994 (USFWS 1994b). The Canadian federal government listed the white sturgeon as Vulnerable in 1990, based on its limited distribution in Canada (Lane 1991). Environment Canada currently places the species in the risk category of Special Concern (Environment Canada 1999). In addition, the upper Columbia River and Kootenay River populations are considered critically imperiled by provincial authorities in British Columbia (B.C. Fisheries 2001a).

White sturgeon populations in both Canada and the United States face a number of conservation challenges.

Overfishing. Excessive catch of white sturgeon from the end of the nineteenth century and into the beginning of the twentieth century left the species seriously depleted throughout its range (Beamesderfer 1999; Waldman 1999; Miller et al. 2001). Today, catch of white sturgeon is prohibited in Canada and either banned or carefully regulated by management agreements in the United States (B.C. Fisheries 2001a; Columbia River Compact 2000; Miller et al. 2001). The years of species recovery took place during the twentieth century, coinciding with an insignificant demand for North American roe during much of this period. Wild populations could again face increased catch pressure if demand increases and conservation measures are relaxed in the United States and Canada. This is particularly true because the large amount of roe (up to 200 pounds [90 kg]) that can be harvested from a single large adult fish (Waldman 1999) presents a strong economic incentive for the take of gravid females if roe prices are high.

Habitat degradation/restricted range. Although habitat conditions impacting individual river systems and populations differ, there is general concern that habitat fragmentation caused by the construction of dams and impoundments for hydroelectric power, irrigation, and water diversion have segmented many once free-flowing rivers in the range of the white sturgeon into more or less isolated habitat pockets of varying suitability. Demand for water for power generation, irrigation, and urban populations means that natural river flows are heavily manipulated by state and regional authorities, which can affect spawning and migration runs (ODFW 1995a; B.C. Fisheries 2001a).

The effects of such activities can be especially severe on small or isolated populations. For example, alteration of the natural flows of the Kootenai River are believed to have affected that sub-population's spawning, egg incubation, nursery, and rearing habitats, and as noted in Box 2, have reduced the overall biological productivity of the Kootenai River and Kootenay Lake (USFWS 1994b, 2000d).

Pollution/water quality. Reduction in water quality associated with human land-use practices such as forestry, dredging, gravel mining and other industries are also believed to impact white sturgeon (B.C. Fisheries 2001a). Industrial pollutants and contaminants, such as chemical run-off from farms, forests, and urban and residential lands pose additional threats. High concentrations of contaminants have been found in the fishes' organs and flesh. The long life span of white sturgeon allows pollutants to concentrate in their flesh, and the bio-accumulation of PCBs and other contaminants is believed to inhibit sturgeon growth and decrease egg and larval survival (PSMFC 1996a).

Rarity/lack of natural reproduction/other. In addition to these environmental hazards, other threats to white sturgeon include lack of recruitment among isolated populations, which could result in extirpation; stress from multiple recaptures in catch-and-release fisheries and the potential for accidental mortality; and the introduction of non-native diseases, competitors, and predators (B.C. Fisheries 2001a; Miller et al. 2001; RL&L Environmental Services 2001a).

3.10 Green Sturgeon *(Acipenser medirostris)*

Illustration by Paul Vecsei

Little is known about the green sturgeon, also known as the Sakhalin or sterlyad sturgeon in its Russian and Asian forms. It is smaller and less abundant than the white sturgeon, with which it shares some riverine and coastal habitats. In North America, green sturgeon are currently confirmed to spawn in only three river systems in the United States. While there are some subsistence green sturgeon fisheries, the species is not as commercially valuable as the white sturgeon because its roe is a poor substitute for Caspian Sea caviar. Most likely as a result, commercial and management interest in the green sturgeon appears not to be as intense as that afforded to its more valuable range mate.

Historic Range and Current Distribution

The green sturgeon is native to both North America and eastern Asia (Japan, Korea, China, and Russia). However, there has been some debate about whether the Asian form is a distinct subspecies, *Acipenser medirostris mikadoi*, or even whether they are two separate species, *Acipenser medirostris* and *Acipenser mikadoi*. In the North American waters of the Pacific Ocean, green sturgeon have been caught from the Bering Sea to Ensanada, Mexico. They are also found in rivers and estuaries from British Columbia south to the Sacramento River in California (California Department of Fish and Game [CDFG] 1995). Figure 12 shows the overall range of the green sturgeon in North America.

Sources differ on the northern limit of the green sturgeon's North American spawning range. NPSSC (1993) reported a "presumed" spawning population of green sturgeon in British Columbia's Fraser River. Other sources indicate that the species is not believed to spawn in Canada or Alaska, although small numbers have been caught in the Fraser and Skeena rivers in British Columbia (CDFG 1995). Such differences highlight the fact that there is very little information on the size, status, or trends of the Canadian green sturgeon population (Environment Canada 2001).

In the United States, green sturgeon occur sporadically throughout coastal Washington, but are not believed to spawn in any Washington rivers (CDFG 1995; NMFS 2003). The species is particularly abundant in the Columbia River estuary, although the species is not believed to spawn in the Columbia River system (CDFG 1995). There are past accounts of the species being observed up to 135 miles (225 km) inland in the Columbia River, but it is currently believed to be found almost exclusively in the lower 36 miles (60 km) of the river and its estuary, and does not occur upstream of Bonneville Dam (CDFG 1995; ODFW 1995b). Summer concentrations of green sturgeon have also been reported in Willapa Bay and Grays Harbor in Washington (NMFS 2003).

South of the Columbia River system, green sturgeon are likely present in all open Oregon estuaries, and there is believed to be considerable movement by the species up and down the coast. Literature sources indicate that while juvenile green sturgeon are found in several of Oregon's coastal rivers, the species is confirmed to spawn only in the Rogue River (NPSSC 1993; CDFG 1995; ODFW 1995b;

NMFS 2003). However, there is some suggestion that green sturgeon may also be spawning in Oregon's Umpqua River. The possibility of current spawning in the Umpqua River is being investigated (R. Beamesderfer, in litt. to TRAFFIC North America, August 2001; NMFS 2003).

In California, green sturgeon have been collected in small numbers in marine waters from the Mexican border to the Oregon border. Only a few have been reported from the southern California coast, with abundance gradually increasing northward of Point Conception. The species is occasionally caught in Monterey Bay. Although green sturgeon have been found in a number of California rivers, spawning is believed to occur at present only in the Sacramento and Klamath river systems. At one time, spawning probably took place in the Eel River as well (CDFG 1995).

The Sacramento River is part of the overall San Francisco Bay system, which consists of San Francisco Bay, Suisin Bay, and the Delta in the Sacramento-San Joaquin River drainage. Within this system, the Sacramento River contains the southernmost known spawning population of green sturgeon, with spawning believed to occur predominantly in the upper Sacramento River. There has been indirect evidence that the species may also spawn in the Feather River, but this has not been substantiated to date (NMFS 2003). Green sturgeon have been reported in the mainstem Sacramento River as far north as river mile 230 (river km 383). It is possible that some spawning also takes place in the San Joaquin River based on the capture of juveniles, but these fish could also have come from the Sacramento River (CDFG 1995).

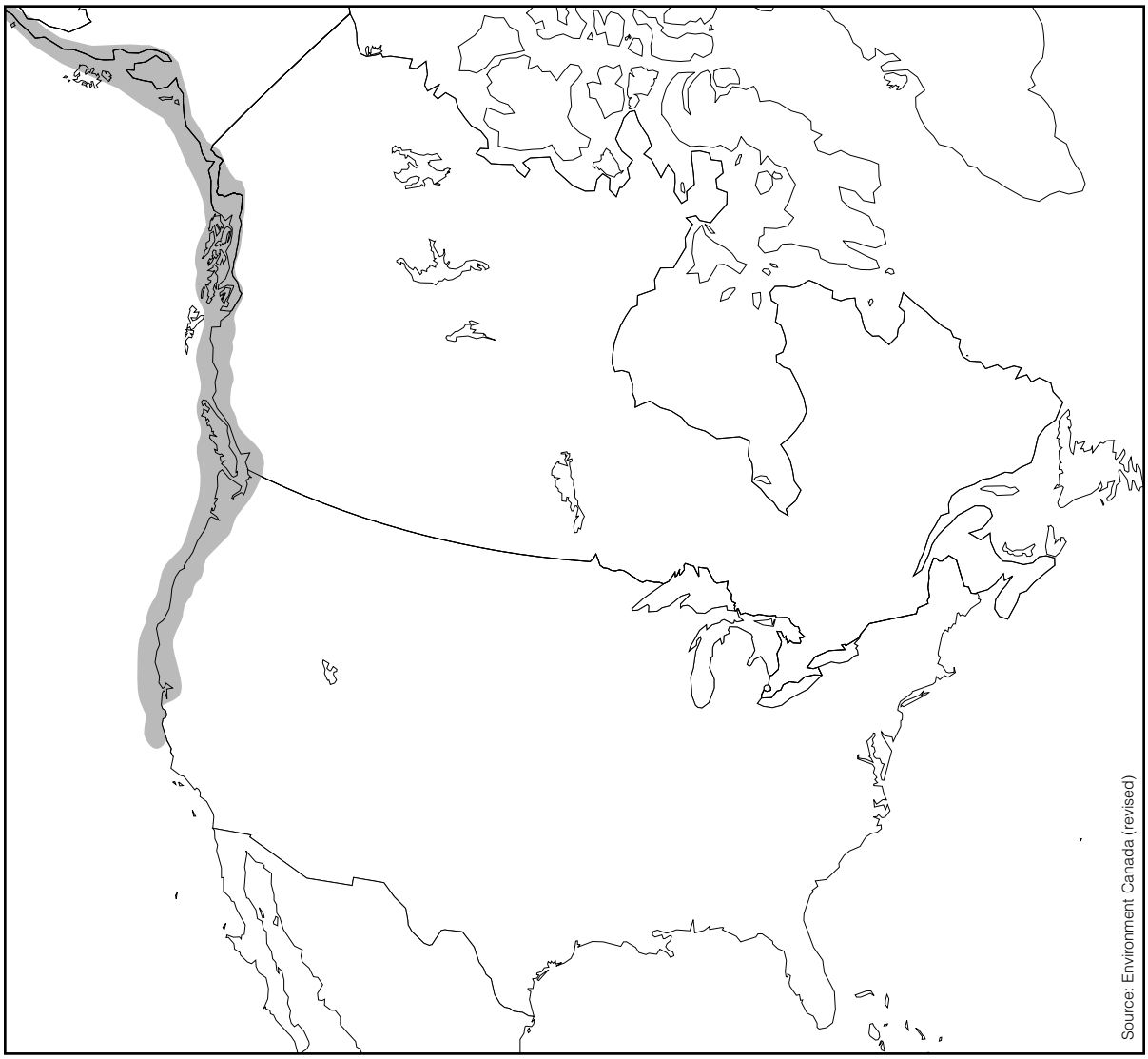
Green sturgeon are found with greater frequency north of San Francisco. It is possible that historic records of sturgeon caught in rivers between San Francisco Bay and the Klamath River refer to green sturgeon, although most early records failed to identify the species. From the Eel River northward, it is believed that green sturgeon predominate in rivers and estuaries along the coast. For example, records in the Humboldt Bay system, which consists of Arcata Bay to the north and Humboldt Bay to the south, are almost exclusively green sturgeon. Green sturgeon have also been reported from the Mad River, although contemporary evidence of their presence is scant and the species would likely be limited to the river's estuary (CDFG 1995).

The largest reported spawning population of green sturgeon occurs in the Klamath River Basin, which includes the Klamath River, Trinity River, and the lower portion of the Salmon River. Both adults and juveniles have been recorded in the mainstem Klamath River. Green sturgeon have been taken by fishermen as far inland as river mile 103 (river km 172), although the usual upstream migration is believed to be Ishi Pishi Falls at approximately river mile 68 (river km 113). A small number of juveniles have been taken as far upstream as river mile 49 (river km 81), but most have been located through seining operations directed at salmonids in the tidewater (CDFG 1995).

Green sturgeon have also been recorded in the Trinity River, which enters the Klamath River as river mile 42 (river km 70). Adults have been taken yearly in a Native American fishery, and spawning migrants are believed to penetrate the Trinity River up to about river mile 43 (river km 72). Green sturgeon have been reported historically in the South Fork Trinity River, a third-order stream that enters the Trinity River above river mile 30 (river km 51). However, a 1964 flood devastated anadromous fish habitat in the sub-basin, apparently resulting in the loss of sturgeon habitat. There have also been reports of adult green sturgeon being sighted in the lower reaches of the Salmon River, a fourth-order stream that enters the Klamath River at about river mile 63 (river km 106). Upriver migration of green sturgeon in the Salmon River is believed to be limited, extending only to about river mile 5 (river km 8) (CDFG 1995).

North of the Klamath River Basin, green sturgeon have been captured in Lake Earl along the coast of Del Norte County, and coastal migrants are believed to occasionally become stranded in Lake Tawala, which is separated from the ocean by a sand spit that is sporadically breached by winter storms. Green sturgeon have also been reported in the Smith River, the northernmost river on the California coast (CDFG 1995).

Figure 11 Green Sturgeon Range



Ecology and Habitat

Although the green sturgeon's life history has not been extensively studied and documented, it is presumed to be similar to that of other sturgeon species. The species relies on differing habitats in streams, rivers, estuarine habitats, and marine waters throughout its life cycle. However, adults are believed to be more marine than white sturgeon, and spend less time in estuaries or fresh water (CDFG 1995).

Little is certain about the species' habitat requirements. Green sturgeon have been reported to prefer spawning in swift currents over a substrate of large cobble, although this can range from clean sand to bedrock (NPSSC 1993; CDFG 1995). Similar to the white sturgeon, green sturgeon are broadcast spawners. Eggs are externally fertilized in relatively high water velocities, probably at depths greater than about 10 feet (>3 meters). Chapman (1999) estimated egg diameter at 3.3–3.7 mm, while CDFG (1995) estimated it at about 3.8 mm. The species' relatively large egg size, thin chorionic layer on the egg, and other characteristics suggest that green sturgeon require colder, cleaner water for spawning than do white sturgeon. Adult green sturgeon have been reported in the Sacramento River, presumably to spawn, when water temperatures ranged between 46 and 57° F (8–14° C). In the Klamath River, green sturgeon migration

upriver occurs between late February and late July. The spawning period is believed to be from March to July, with a peak between mid-April and mid-June (CDFG 1995).

Hochleithner and Gessner (1999) reported sexual maturity in males at 8–10 years and in females at 10–12 years, with intervals between spawnings at 2–6 years. However, neither age at sexual maturity nor the spawning intervals of male or female green sturgeon have been definitively established. Chapman (1999) estimated female fecundity at 600–1,000 eggs per kg of female body weight, and CDFG (1995) reported that female green sturgeon may produce 60,000 to 140,000 eggs. Juveniles might spend several years in fresh water before moving to saltwater environments (NPSSC 1993; CDFG 1995; PSMFC 1996b; Hochleithner and Gessner 1999).

Age and growth information on green sturgeon is sparse, and little is known about the marine phase of this sturgeon's life cycle except that it is highly migratory. Tagged fish are often recaptured in river systems or estuaries hundreds of miles away. While longevity is not certain, the largest fish in the Klamath River have been aged at 40 years, although this may be an underestimate. The average length at age 25 is estimated at about 7 feet (~2 meters) and the largest green sturgeon recorded weighed around 325 pounds (159 kg) (NPSSC 1993; CDFG 1995; PSMFC 1996b; Chapman 1999).

Adult and juvenile green sturgeon are benthic feeders, seeking out benthic invertebrates and small fish (NPSSC 1993). Juveniles in the Sacramento-San Joaquin Delta have been reported to feed on opossum shrimp (*Neomysis mercedis*) and amphipods (*Corophium* sp.). Stomach content analysis of adult sturgeon captured in Washington revealed a primary diet of sand lances (*Ammodytes hexapterus*) and callianassid shrimp. Green sturgeon in the Columbia River estuary are known to feed on anchovies, and may also feed on clams (CDFG 1995).

Historic Catch

Historically, green sturgeon were not targeted as a food fish (its flesh was once considered poisonous), and roe was rarely harvested. Therefore, there is little historical information available on levels of directed take. As the market perception of the green sturgeon changed, however, some fisheries developed. The commercial catch in the lower Columbia River averaged about 200 to 500 fish annually between 1941 and 1951; 1,400 fish annually between 1951 and 1971; and 2,000 to 4,000 fish annually from 1971 to 1990 (CDFG 1995; Waldman 1999). By decade, CDFG (1995) reported that the annual commercial green sturgeon catch in the Columbia River estuary averaged 1,440 fish during the 1960s, 1,610 fish during the 1970s, and 2,360 fish during the 1980s. Records for some years indicate notably high catches. In 1986, the green sturgeon catch in the Columbia River estuary was 6,000, and 4,900 were taken in 1987. These catches occurred in a directed gill net fishery that has since been closed (CDFG 1995).

Today, a small Native American gill net fishery remains on the Klamath River in California. According to the oral history of Yurok tribal elders, this subsistence fishery has existed since "historical" times—at least since the turn of the twentieth century—and quite likely earlier (CDFG 1995; Waldman 1999).

Conservation Status and Challenges/Threats

IUCN classified the green sturgeon as Vulnerable in the Red List 2000 (IUCN 2001). The species was placed in CITES Appendix II at COP 10 in June 1997 with all other previously unlisted sturgeon species. The listing entered into effect in April 1998 (CITES 2001a). Decisions adopted at COP 10 with regard to the revision of CITES Appendices were published in the Official Journal of the European Communities in November 1997, to update the annexes to Regulation (EC) No. 338/97 accordingly (Caroline Raymakers, TRAFFIC Europe, *in litt*. to TRAFFIC North America, October 2001). A listing for the green sturgeon in the EU's Annex B entered into effect on April 1, 1998 concurrent with the CITES listing (CITES 2001a).

Canada designated the green sturgeon as a Species of Special Concern in 1987 (Environment Canada 2001). The species is not federally protected in the United States. However, in June 2001 NMFS received a petition from the Environmental Protection Information Center, Center for Biological

Diversity, and Waterkeepers Northern California requesting that NMFS list the North American green sturgeon as either an endangered or threatened species under the ESA, and that it designate critical habitat for the species concurrently with the listing. In December 2001, NMFS announced a finding that the petition presented substantial scientific information indicating that the request may be warranted, and undertook a status review of the green sturgeon to make a determination (NMFS 2001).

NMFS completed the review in January 2003. The agency determined that there are two distinct population segments of green sturgeon that qualify as species under the ESA (one being the Sacramento River population and the other being the Klamath and Rogue River populations, with the Eel River identified as the point of geographic separation), but that neither warranted listing as a threatened or endangered species at the time of the review. Because of remaining uncertainties about their population structure and status, NMFS decided to add both population segments to the agency's list of candidate species and will re-evaluate their status in five years (NMFS 2003).

Green sturgeon are believed to face several conservation challenges or threats.

Habitat degradation/restricted range. Similar to other sturgeon species, green sturgeon are sensitive to habitat degradation or alteration in their native rivers and estuaries. Research indicates that water flow rates are a determinant of green sturgeon larval survival, as is also found in other sturgeon species. It is presumed that the species has a specific set of water flow, depth, and substrate requirements for spawning and for early life stage histories. Thus, water diversions for municipal and industrial uses, irrigation projects, and power generation that reduce the amount of water in rivers likely have negative effects, because suitable conditions for spawning and development of young green sturgeon probably occur less frequently than they once did (CDFG 1995; PSMFC 1996b; Environment Canada 2001). It is believed that California has lost a number of green sturgeon spawning populations in the past several decades, for example the Eel River and South Fork Trinity River populations. Other North American spawning populations may be at risk because of flow regimes affected by water projects (CDFG 1995).

Overfishing. The lack of available evidence on the green sturgeon makes it difficult to assess the impact of historic or current fisheries on the species. However, it is possible that the exploitation of green sturgeon in commercial, sport, Native American, and illegal fisheries (as well as incidental catch in fisheries not targeting the species) may have affected the species' abundance (CDFG 1995). Because the green sturgeon is thought not to have been as historically abundant as the white sturgeon, even lower rates of catch may not be sustainable. The uncertainty of the green sturgeon's status, life history characteristics, and other factors raise concerns about the potential threat of excessive catch if demand for North American roe increases.

Pollution/Water quality. Accumulation of PCBs and other contaminants may reduce sturgeon survival, because of impacts to eggs and larvae (PSMFC 1996b; Environment Canada 2001). The precise effects of toxic substances, from heavy metals to pesticides, are uncertain (CDFG 1995).

IV. Management and Regulation in the United States and Canada

Paddlefish and sturgeon management in North America varies widely by species, and depends largely on distribution, conservation status, demand in commercial and/or recreational fisheries, funding availability, and the level of concern among wildlife and fisheries authorities in specific jurisdictions. Conservation status also plays a significant role in establishing whether species are strictly protected, with no catch allowed, or managed for catch.

Sturgeon and paddlefish populations occur within and across so many jurisdictional boundaries that it is difficult to adequately describe their overall management. There is no such thing as a central "Sturgeon and Paddlefish Management Authority" coordinating conservation efforts for all of the species and agencies involved in management and regulatory decisions. Given the differences among the species' ranges, management needs, and the network of legal boundaries across which they migrate, such an approach would be difficult, if not impossible, to coordinate. Furthermore, anadromous species require different management approaches than freshwater species, and endangered or threatened species are managed under the strictures of individually tailored recovery plans.

Numerous federal, state and provincial laws and regulations in the United States and Canada directly or indirectly address management of North American paddlefish and sturgeon species and populations. Some of the key federal laws are summarized in Box 3. In addition to federal, state, and provincial agencies; commissions; and other bodies designated to implement pertinent laws and regulations, there are also several inter-jurisdictional and international commissions that function between states, or between the United States and Canada, and play a critical role in the management of several species.

The two Atlantic coast anadromous species (Atlantic sturgeon and shortnose sturgeon) are managed by federal, state, and provincial authorities within the United States and Canada. Management of the shortnose sturgeon in the United States is also subject to a recovery plan under the ESA because of the species' designation as endangered. The two anadromous Pacific coast species, white sturgeon and green sturgeon, are managed primarily by state and provincial authorities; however, the United States' Columbia River population of white sturgeon also falls under the jurisdiction of the congressionally established Columbia River Compact, as well as a joint management agreement between Oregon and Washington.

The endangered Alabama sturgeon and pallid sturgeon, and the threatened Gulf sturgeon, are managed under the protection and provisions of the ESA, as they are indigenous to the United States. Paddlefish and shovelnose sturgeon, whose ranges are also limited to the United States, are not listed under the ESA, and populations are managed independently by those states in whose waters they reside. The lake sturgeon inhabits both the United States and Canada, but is not federally listed as endangered or threatened in either country. The species is managed by those states and provinces in which it is found, many of which classify it as a threatened or endangered species under state law, with input where appropriate from the bilateral Great Lakes

Box 3. Federal Laws and Regulations Relevant to Acipenseriformes in the United States and Canada*

There are numerous federal laws that may directly or indirectly impact the management of sturgeon and paddlefish species and populations in the United States and Canada. Some of these are listed below.

United States

- The Magnuson-Stevens Act (16 U.S.C. 1801 et. seq.) provides regional fishery management councils with the authority to prepare plans for the conservation and management of federally managed fisheries in the EEZ (subject to approval by the Secretary of Commerce).
- The Lacey Act of 1981 (16 U.S.C. 3371–3378) makes it a federal crime to import, export, or transport in interstate commerce any fish or wildlife taken in violation of a state, federal, Indian tribal, or international law.
- The Endangered Species Act of 1973 (16 U.S.C. 1531–1543) provides for the conservation of plant and animal species federally listed as threatened or endangered.
- The Federal Power Act (16 U.S.C 791–828) provides for protection, mitigation of damages, and enhancement of fish and wildlife resources (including anadromous fish) impacted by hydroelectric facilities regulated by the Federal Energy Resources Commission.
- The Anadromous Fish Conservation Act (16 U.S.C. 757a–757f) authorizes the Secretaries of Interior and Commerce to enter into cost-sharing with states and other non-federal interests for the conservation, development, and enhancement of the nation's anadromous fish.
- The Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5101–5109) authorizes the Secretary of Commerce to provide financial assistance to the Atlantic States Marine Fisheries Commission and to Atlantic coastal states to adopt and implement fishery management plans for coastal fisheries, and allows the Secretary to impose a moratorium on all fishing for a species within the waters of a state found not in compliance with the adopted plan.
- The Fish and Wildlife Coordination Act (16 U.S.C. 661–666) provides for consideration of fish and wildlife habitat values in conjunction with federal water development activities.
- The Federal Water Pollution Control Act (33 U.S.C. 1251–1376—"Clean Water Act") mandates federal protection of water quality and provides for assessment of injury, destruction, or loss of natural resources caused by the discharge of pollutants.
- The Rivers and Harbors Act of 1899 requires a permit from the Army Corps of Engineers to place structures in navigable waters of the United States or modify a navigable stream by excavation or filling activities.
- The National Environmental Policy Act (42 U.S.C. 4321–4347) requires an environmental review of all federal activities.
- The Coastal Zone Management Act (16 U.S.C. 1451–1464) and Estuarine Areas Act state that federal activities must comply with comprehensive state planning programs established to enhance, protect, and utilize coastal resources.
- The Marine Protection, Research and Sanctuaries Act of 1972 and the Shore Protection Act of 1988 protect fish habitat through establishment and maintenance of marine sanctuaries.

Canada

- The Fisheries Act allows the federal government to make decisions for the conservation and protection of fish habitat essential to sustaining Canada's freshwater and marine fisheries resources, Canadian commercial and recreational fisheries, and Aboriginal fisheries.
- The Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act (WAPPRIITA) controls the international trade and interprovincial transport of certain wild animals and plants, as well as their parts and derivatives, and is the Canadian law that implements CITES.
- The Canadian Environmental Protection Act protects the environment, human life and health from the risks associated with toxic substances, and includes sections protecting the marine environment from land-based pollution sources.

* Sources: Buck (1995); NMFS/USFWS (1998); DFO (2000); Environment Canada (2002).

Fisheries Commission. A number of states in the Mississippi River Basin have also joined to form the Mississippi Interstate Cooperative Resource Association (MICRA), an effort to facilitate coordination and cooperation in the management of species located within the greater Mississippi River Basin.

Moreover, the purposes for which individual North American acipenseriform species are managed differ. Management efforts for species or populations listed as endangered or threatened under federal, state, or provincial laws in the United States and Canada focus on preventing extirpation or extinction, and on species recovery. Management efforts regarding other, non-listed species focus on a different set of objectives. Elser (1986) noted that the traditional bottom line in fisheries management has been to produce the greatest catchable surplus for all user groups. Management must balance several approaches to reach this goal, including regulation of catch, protection of fish habitat, and encouragement of public support for conservation. Thus, regulations are often designed to allow for survival of a fairly large number of breeding adults, protect smaller fish so they can reach maturity, and protect fish during spawning season.

Fisheries authorities are subject to pressures from numerous constituencies as they attempt to devise appropriate management or recovery plans for individual sturgeon and paddlefish species and populations in North America. Combs (1986) observed: "Fisheries have been regulated on the basis of politics, social pressure, whim, and sometimes biology." While fisheries managers at the federal, state, and provincial levels are overwhelmingly dedicated to the pursuit of sound conservation and management practices, divergent and often conflicting opinions, goals, and interests have led to frequent tensions among various stakeholder groups (biologists, commercial fishermen, industry, agriculture, etc.). Such inherent friction in the formulation of sturgeon and paddlefish management programs poses a continual challenge to the efficacy of management efforts.

Finally, in states and provinces that continue to allow commercial and/or sport catch of resident populations of sturgeon or paddlefish, the regulatory tools employed to manage such catch vary by species and by jurisdiction. Sport fishing restrictions commonly include creel limits (to limit individual success, thereby ensuring a "fair distribution" of the catch among participants), open and closed seasons, size limits, gear restrictions, prohibition of high-grading (removing and releasing smaller fish from the creel so that larger fish can be caught without exceeding the limit), and sanctuaries or closures of certain waters. Commercial restrictions often include size limits, seasons, closures of designated waters, gear restrictions, and catch reporting requirements. Catch quotas have also been used for many years, particularly in saltwater commercial fisheries. However, such quotas are only effective when sufficient data are available on a population to set realistic and sustainable limits (Combs 1986; Elser 1986).

The following section examines the management issues involved with each species; federal, state, provincial, and international laws that apply to their management; regulatory approaches and tools being used at present; and finally, who is responsible for implementation. Two caveats are important to note. First, the summaries included herein represent a "snapshot" in time. Management and regulatory regimes are not static, but rather dynamic. The most effective management schemes may very well be those that can best adapt to new information and circumstances. Therefore, as time passes, many of the specific regulations and programs outlined in this report are likely to change. Second, because TRAFFIC's primary focus is on sustainable take and trade of wildlife, comparably more attention is given herein to those native acipenseriform species for which catch and trade is currently legal in the United States or Canada. TRAFFIC encourages readers interested in more details on species listed as threatened or endangered, or not commonly associated with catch and trade, to refer to the specific conservation and management plans in place regarding those species.

4.1 Atlantic Sturgeon

The United States and Canada manage the Atlantic sturgeon somewhat differently, although the two countries' approaches have a historic similarity. The species is not listed as federally threatened or endangered in either country, but both nations have created frameworks for cooperation between federal authorities and state or provincial fishery managers. However, whereas Canada continues to allow a regulated catch, the United States has imposed a moratorium on directed take of Atlantic sturgeon in U.S. waters. It is anticipated that this moratorium will be in place for several decades (ASMFC 1998b; NMFS/USFWS 1998).

Canada

Atlantic sturgeon and their habitat are protected and managed in Canada under the Federal Fisheries Act (Anon. 2001a). In the Maritime provinces, jurisdiction for the management and regulation of Atlantic sturgeon fisheries lies with the Canadian Department of Fisheries and Oceans (DFO). The provincial government in Quebec manages a separate Atlantic sturgeon fishery inland on the St. Lawrence River. Management regulations, conservation measures, and contemporary catch levels of Atlantic sturgeon in Canada are as follows.

The Maritime Provinces

The Atlantic sturgeon fishery in these provinces is governed by a limited number of licenses, season limits, gear restrictions, and minimum size limits for catchable fish. This is a "sunset" commercial fishery, in which non-transferable licenses terminate with the death of the existing licensee, and new licenses are no longer available—no new sturgeon licenses have been issued since the mid-1980s. In 1997, there were 10 commercial licenses issued for Atlantic sturgeon in the Maritime provinces, nine on the Saint John River, New Brunswick and one on the Shubenacadie River, Nova Scotia (NMFS/USFWS 1998). As of 2001, there were nine licensed fishermen on the Saint John River, and none in the Gulf of St. Lawrence areas of New Brunswick, Nova Scotia, or Prince Edward Island (Anon. 2001a). This fishery will end when all current license holders are no longer fishing, unless future measures are taken to continue the fishery (NMFS/USFWS 1998; Anon. 2001a). There are no commercial quotas for Atlantic sturgeon in New Brunswick and Nova Scotia, because, according to Canadian management authorities, it has been determined that there is insufficient biological data to use quotas as a management tool (Anon. 2001a).

Each Atlantic sturgeon fishing license authorizes specific amounts and type of gear. The legal minimum gill net mesh size is 13.2 inches (33 cm), to ensure that the fishery targets only adult Atlantic sturgeon. The minimum size limit for catchable fish is 48 inches (120 cm). The season is closed from June 1–30 to protect spawning fish. Atlantic sturgeon catch in the Saint John River fishery consists mostly of sexually mature fish, averaging 74 inches long (range 60 to 92 inches) and 18 years of age (range 10 to 31 years) (B. Jessop, DFO, unpublished data, cited in Anon. 2001a).

Catch levels in the fishery peaked in 1988 at 44 metric tons (44,000 kg; 96,800 pounds, but have declined in recent years (R. St. Pierre, IUCN/SSC Sturgeon Specialist Group, *in litt*. to IUCN/SSC Wildlife Trade Programme, September 28, 2001). Data provided by the DFO indicated that harvests between 1995 and 2002 were in the range of 2.5 to 14 metric tons (2,500–14,000 kg; 5,700–30,000 pounds) (P. Hall, DFO, *in litt*. to TRAFFIC North America, September 28, 2001; pers. comm. R. Bradford, DFO, February 2003). In 2001, the harvest was reported as approximately 10,000 kg (22,000 pounds), but dropped to 5,000 kg (11,000 pounds) in 2002. The drop in catch in 2002 may be explained by the death of one of the remaining licensed fishermen, who had accounted for a significant proportion of the catch in previous years (pers. comm., R. Bradford, DFO, February 2003).

Table 4.1.1 shows reported Atlantic sturgeon landings in New Brunswick (Saint John River Estuary/Bay of Fundy) and Nova Scotia (Bay of Fundy/Atlantic Ocean) from 1995 through 2002. The final column in the table displays DFO statistics on the percentage of the total yearly catch that was taken within the Saint John River estuary in New Brunswick. It illustrates that the Saint John River fishery has

Table 4.1.1 Atlantic Sturgeon Landings (kgs) in New Brunswick and Nova Scotia, 1995–2002*

Province	1995	1996	1997	1998	1999	2000	2001	2002
New Brunswick	10,457	13,850	11,341	6,164	3,231	2,520	10,342	5,069
Nova Scotia	0	0	275	4,210	41	0	0	0
Total:	***10,457***	***13,850***	***11,616***	***10,374***	***3,272***	***2,520***	***10,342***	***5,069***
% taken within the Saint John River Estuary	98	99	97	59	99	95	100	100

* Source: R. Bradford, DFO, *in litt.* to TRAFFIC North America, February 2003.

accounted for an overwhelming majority of the total Atlantic sturgeon catch in recent years.

Small amounts of Atlantic sturgeon bycatch (less than 0.3 tons per year) were reported in the decade leading up to 1997 in non-sturgeon fisheries. Retention of bycatch has been prohibited in the Maritime provinces since 1995 (NMFS/USFWS 1998; Anon. 2001a). The landing of 4.2 tons of bycatch in 1998 by the groundfish industry (coastal Bay of Fundy waters) led to charges being brought by DFO. All groundfish vessels in the region now have conditions on their licenses specifically prohibiting the retention of any sturgeon. The zero bycatch rule in the region's estuarial, coastal, and marine fisheries also helps to protect ocean migrant sturgeon that are known to occur in the area, and could have origins either in the Saint John River or other east coast populations (pers. comm., R. Bradford, DFO, February 2003).

Quebec

The Quebec Ministere de l'Environnement et de la Faune regulates an Atlantic sturgeon fishery in the St. Lawrence River, from just east of Quebec City to about Trois-Pistoles (approximately a 90-mile [150 km] stretch). Prior to 1994, regulations designed to conserve Atlantic sturgeon stocks in the fishery limited the number of fishing permits to 35 and mandated a minimum gill net mesh size (stretched) of 7.2 inches (18 cm). In 1995, Quebec established a season from May 1 to September 30, and set a size limit of 40 to 68 inches (100–170 cm) fork length, which was reduced in 1996 to 40 to 60 inches (100–150 cm) (NMFS/USFWS 1998; Anon. 2001a).

In the spring of 1997, in addition to the maximum size limit of 60 inches (150 cm), Quebec established a catch quota and Total Allowable Catch (TAC) of 6,015 fish (approximately 60 metric tons). In 1998, the allowable gill net mesh size (stretched) was changed to between 7.6 and 8.1 inches (19–20.3 cm) (Anon. 2001a). Catch in the Quebec fishery is consequently composed mostly of immature sturgeon measuring less than 60 inches (150 cm) long and 5 to 10 years of age (Caron and Tremblay 1999; Anon. 2001a). Quebec's catch quota and TAC have gradually declined since 1997, as shown in Table 4.1.2.

Fisheries authorities in Quebec monitor captures of Atlantic sturgeon in collaboration with commercial fishermen in an effort to measure the effectiveness of the new regulations. At present, the province has determined that a catch level of less than 60 metric tons annually is sustainable, and that the regulations have achieved this objective (Caron and Tremblay 1999; Anon. 2001a).

Table 4.1.2 Reported Catch and Total Allowable Catch (TAC) for Atlantic Sturgeon in Quebec, 1997–2000*

Year	Catch Quota (pounds/kg)	Total Allowable Catch (TAC)
1997	145,502 lb (65,476 kg)	6,015 fish
1998	108,024 lb (48,611 kg)	5,297 fish
1999	103,615 lb (46,627 kg)	5,297 fish
2000	116,843 lb (52,579 kg)	4,767 fish

* Source: Anon. 2001a.

The United States

All U.S. Atlantic coast states have instituted a moratorium on catch and possession of Atlantic sturgeon, eliminating the threat to the species from directed commercial fishing, as well as the incentive to keep sturgeon obtained as bycatch. A brief recent history of how the moratorium came into being, key management decisions, and additional information on state conservation measures for Atlantic sturgeon follows.

The Atlantic States Marine Fisheries Commission (ASMFC), authorized under the terms of the Atlantic States Marine Fisheries Compact, has the authority to develop, implement, and enforce Atlantic sturgeon fisheries management plans. The purpose of ASMFC is to promote better utilization of the fisheries of the Atlantic seaboard "by the development of a joint program for the promotion and protection of such fisheries, and by the prevention of the physical waste of the fisheries from any cause" (NMFS/USFWS 1998).

In 1990, ASMFC adopted a Fishery Management Plan (FMP) for Atlantic sturgeon, regulating catch and coordinating stock assessments from Maine to Florida. The 1990 FMP recommended that each state control catch by choosing one of three options: (1) adopting a minimum total length of at least seven feet (2.13 meters) and instituting a monitoring program with mandatory reporting of commercial landings; (2) imposing a moratorium on all catch; or (3) submitting an alternative plan to the ASMFC Atlantic Sturgeon Plan Review Team. All east coast states except New York and New Jersey chose one of the first two options. New York and New Jersey instituted a five-foot (1.5 meter) minimum size limit with seasonal restrictions, quotas, mandatory reporting, and extensive monitoring (NMFS/USFWS 1998).

In 1993, ASMFC's original enabling legislation was amended by Congress as the Atlantic Coastal Fisheries Cooperative Management Act, empowering the Secretary of Commerce to enforce mandatory compliance of FMP recommendations approved by ASMFC. The Secretary was charged with imposing a catch moratorium on states that fail to comply with the recommendations of specific FMPs approved by ASMFC. In 1996, a review of the 1990 Atlantic sturgeon FMP found that the then-current seven-foot minimum size length protected only 50% of spawning females and approximately 80% of spawning males in the stock. Furthermore, the five-foot minimum length adopted in New York and New Jersey was believed to result in recruitment overfishing. The review also noted that New York had exceeded its quota in 1994 and 1995. By 1997, when a draft review of the FMP was compiled, most participating states had closed their commercial fisheries or reduced the allowable quota to zero. Only Delaware maintained an open fishery, still allowing a seven-foot minimum size. The 1997 FMP draft review concluded that the recommendations in the 1990 FMP would not bring about the recovery of the species, and should be amended. Recommendations in the Plan Amendment included a complete catch moratorium, enhanced monitoring programs, specifications concerning the role of cultured fish in stock enhancement and restoration programs, and monitoring and commitment to reduce bycatch. The amendment to the FMP was adopted in June 1998 (ASMFC 1998b; NMFS/USFWS 1998).

The ASMFC formalized the moratorium as a mandatory compliance measure in all jurisdictions; it cannot be lifted for a spawning stock until 20 protected year classes of females are established. Because Atlantic sturgeon reach maturity at an average age of 18 years, it is anticipated that the moratorium will be in effect until at least 2039 (41 years from implementation). Consideration to lifting the moratorium may be given in areas where fish mature at younger ages, or where state moratoria were in effect prior to 1998 (prohibitions on catch in six jurisdictions—Pennsylvania, District of Columbia, Potomac River Fisheries Commission, Virginia, South Carolina, and Florida—were in place prior to 1990, and were entered into force in all other jurisdictions during various years thereafter) (NMFS/USFWS, 1998). The moratorium also includes a complete ban on the possession of wild Atlantic sturgeon of U.S. origin or their parts; a request to the Secretary of Commerce to ban catch and possession of Atlantic sturgeon in the Exclusive Economic Zone (EEZ); requirements that states assess and

annually report capture and mortality of Atlantic sturgeon caught as bycatch in other fisheries; requirements that states authorizing culture of sturgeons (Atlantic or non-indigenous) mandate that permittees take appropriate measures to prevent escape or disease transmission; requirements that states report annually to ASMFC on their habitat protection and enforcement measures; and requirements that states conduct periodic monitoring of populations (ASMFC 1998b; NMFS/USFWS 1998).

Every one of the eastern coastal U.S. states has taken legislative or regulatory action to enforce the catch moratorium in their home waters. Thus, the 1998 moratorium is enforced under state as well as federal laws; state fisheries management agencies enforce the catch moratorium as authorized by specific state regulations. In addition, several states have included the Atlantic sturgeon on state lists of rare, threatened, or protected species. Delaware and Massachusetts, for example, classify the Atlantic sturgeon as a state endangered species (Delaware Division of Fish and Wildlife 2000; Massachusetts Division of Fisheries and Wildlife 2002). Connecticut and Pennsylvania classify the species as threatened (Pennsylvania Department of Conservation and Natural Resources [PDCNR] 2001a; Connecticut Department of Environmental Protection 2002). Florida, North Carolina, and Virginia have designated the Atlantic sturgeon as a Species of Special Concern (Florida Fish and Wildlife Commission 1997; Le Grand et al. 2001; Roble 2001). In these states, along with the moratorium on catch, Atlantic sturgeon also receive the legal protections conferred by such designations under applicable state statutes. Rhode Island classifies the Atlantic sturgeon as a "State Historical" species, which the state defines as native species which have been documented during the last 100 years, but which are currently unknown to occur (Rhode Island Natural Heritage Program 2002).

4.2 Gulf Sturgeon

The Gulf sturgeon is indigenous to the United States, where management efforts are somewhat similar to those for the Atlantic sturgeon. Management approaches for both species emphasize cooperation between federal and state authorities, including a regional fisheries management commission. The Gulf States Marine Fisheries Commission (GSMFC) is responsible for the coordination of management schemes between the federal government and range states for Gulf sturgeon, among other species. Catch and possession of Gulf sturgeon is illegal, as is the case for the Atlantic sturgeon. Many federal laws that directly or indirectly pertain to conservation of the Gulf sturgeon are the same as those for the Atlantic sturgeon, as are the agencies involved in conservation and law enforcement efforts.

A key difference in the management of the Gulf sturgeon, however, is its status as a threatened species under the ESA, following the species' 1991 listing. Section 6(a) of the ESA provides for cooperation with affected states for the purpose of conserving threatened and endangered species. The Departments of Interior and Commerce can enter into cooperative agreements with a state, provided the state has an established program for the conservation of the species. All four states within the range of the Gulf sturgeon (Florida, Alabama, Mississippi, and Louisiana) have entered into Section 6 agreements with USFWS (USFWS/GSMFC 1995). Some of the legal and regulatory steps taken by the range states that are most relevant to this report actually predate the Gulf sturgeon's federal listing under the ESA in 1991. For example, laws or regulations prohibiting all take of any sturgeon species in state waters were implemented in Alabama in 1972, in Mississippi in 1974, in Florida in 1984, and in Louisiana in 1990 (USFWS/GSMFC 1995). The Gulf sturgeon is also listed as an endangered species in Mississippi, a threatened species in Alabama and Louisiana, and a species of special concern in Florida and Georgia (based on historical presence) (Florida Fish and Wildlife Commission 1997; Godwin 1999; Mississippi Department of Wildlife, Fisheries and Parks 2000a; Georgia Department of Natural Resources 2002; Louisiana Department of Wildlife & Fisheries 2002).

Additionally in 1994, 14 federal agencies, including the U.S. Army Corps of Engineers, the NMFS, USFWS, the Department of Defense, the Minerals Management Service, the National Park Service, the Coast Guard, and the Environmental Protection Agency

signed a Memorandum of Understanding (MOU) to establish a general framework for cooperation and participation in accordance with responsibilities for the Gulf sturgeon under the ESA. The MOU charged the involved federal agencies to work with interested members of the public, states, Indian Tribal governments, and local governments to protect and manage species listed under the ESA and the ecosystems upon which those populations depend. That MOU also applied to inter-agency cooperation to facilitate recovery of the Gulf sturgeon (USFWS/GSMFC 1995).

In 1995, USFWS and the GSMFC published the "Gulf Sturgeon Recovery/Management Plan," which included one short-term and two long-term objectives. The short-term objective was, primarily, "…to prevent further reduction of existing wild populations of Gulf sturgeon within the range of the subspecies." The first long-term objective was "…to establish population levels that would allow delisting of the Gulf sturgeon by management units. Management units could be delisted by 2023 if the required criteria are met. While this objective will be sought for all management units, it is recognized that it may not be achievable for all management units." The second long-term objective was, principally, "…to establish, following delisting, a self-sustaining population that could withstand directed fishing pressure within management units. Note that the objective is not necessarily the opening of a management unit to fishing, but rather, the development of a population that can sustain a fishery." The Plan goes on to outline recommendations for specific recovery actions that address threats to the species (USFWS/GSMFC 1995).

In June 2002, in response to a federal court order, USFWS and NMFS proposed to designate critical habitat for the Gulf sturgeon along portions of rivers, estuaries, and the marine coastline in Alabama, Florida, Louisiana, and Mississippi. The proposal included portions of the following Gulf of Mexico rivers and tributaries: the Pearl and Bogue Chitto rivers in Louisiana and Mississippi; the Pascagoula, Leaf, Bowie, Big Black Creek and Chickasawhay rivers in Mississippi; the Escambia, Conecuh, and Sepulga rivers in Alabama and Florida; the Yellow, Blackwater, and Shoal rivers in Alabama and Florida; the Choctawhatchee and Pea rivers in Florida and Alabama; the Apalachicola and Brothers rivers in Florida; and the Suwannee and Withlacoochee rivers in Florida. Estuarine and marine areas proposed for designation included Lake Pontchartrain (east of the Lake Pontchartrain Causeway), Lake Catherine, Little Lake, The Rigolets, Lake Borge, Pascagoula Bay and Mississippi Sound systems in Louisiana and Mississippi, and sections of the adjacent state waters within the Gulf of Mexico; the Pensacola Bay system in Florida; the Choctawhatchee Bay system in Florida; Santa Rosa Sound in Florida; near-shore Gulf of Mexico in Florida; the Apalachicola Bay system in Florida; and Suwannee Sound and adjacent state waters within the Gulf of Mexico in Florida. These geographic areas encompass approximately 1,580 river miles and 2,333 square miles of estuarine and marine habitats (USFWS 2002c). As of the time of this report, the period of public hearings and public comment on the proposal had not yet been completed, and the final outcome of the proposed designations remained unknown.

4.3 Shortnose Sturgeon

Management of the shortnose sturgeon combines aspects of management plans for Atlantic sturgeon and Gulf sturgeon. Similar to the Atlantic sturgeon, the shortnose sturgeon's range extends to portions of the Canadian and U.S. Atlantic coast, but management of the species differs between the two countries. Like the Gulf sturgeon, the shortnose sturgeon is federally protected in the United States because of a 1967 endangered species listing, now administered under the ESA.

Canada

Canadian fisheries regulations for the Maritime Provinces continue to allow the catch of "sturgeon" by angling and by gill nets in the Saint John River, New Brunswick (the only Canadian river in which the species has been located), but do not specify shortnose or Atlantic sturgeon. The catch season is regulated under the Federal Fisheries Act and the Maritime Provinces Fishery Regulations. These regulations mandate permits for fishermen and a

closed season from June 1 to June 30 (to protect spawning runs); they also prohibit fishing with any gill net with a mesh size smaller than 330 mm (13.2 inches), and retention of any sturgeon measuring less than 120 cm (48 inches) in length (Maritime Provinces Fisheries Regulations, SOR/93-55). There is no daily bag limit, but the minimum size restriction should largely eliminate the possibility that shortnose sturgeon could be retained, given the species' relatively small size (pers. comm., R. Bradford, DFO, February 2003).

The United States

All U.S. states within the current and/or historic range of the shortnose sturgeon have enacted laws and regulations prohibiting take and possession of the species. Shortnose sturgeon are also classified as an endangered species under state laws in Connecticut, Florida, Georgia, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, South Carolina, and Virginia (Florida Fish and Wildlife Commission 1997; Maryland Department of Natural Resources 1998; Le Grand et al. 2001; New York State Department of Environmental Conservation 2001; PDCNR 2001b; Roble 2001; Connecticut Department of Environmental Protection 2002; Georgia Department of Natural Resources 2002; Massachusetts Division of Fisheries and Wildlife 2002; New Hampshire Fish and Game Department 2002; New Jersey Division of Fish and Wildlife 2002; South Carolina Department of Natural Resources 2002).

The shortnose sturgeon was first listed as a federally endangered species in the United States on March 11, 1967, under the provisions of the Endangered Species Preservation Act; the original listing notice did not cite specific reasons for the designation. Citing pollution and overfishing as reasons for the shortnose sturgeon's presumed decline, USFWS determined that the species continued to meet the criteria for "endangered" under subsequent definitions specified in the 1969 Endangered Species Conservation Act and the 1973 ESA (NMFS 1998). A 1973 Resource Publication stated that shortnose sturgeon were "in peril… gone in most of the rivers of its former range [but] probably not as yet extinct" [U.S. Department of Interior (1973), cited in NMFS (1998)]. NMFS assumed jurisdiction for the species under a 1974 government reorganization plan (NMFS 1998).

Section 4(f)(1) of the ESA required NMFS and USFWS to develop and implement recovery plans for threatened or endangered species, unless it was determined that such a plan would not promote species recovery. NMFS established the first Shortnose Sturgeon Recovery Team (SSRT) in 1977 to develop a recovery plan for the species. Although a draft plan was completed by the team in 1981, NMFS elected to complete a status review for the shortnose sturgeon before publishing a final recovery plan (NMFS 1998).

A Shortnose Sturgeon Status Review was drafted in 1987. Its most significant conclusions were a decision to change the status of the Connecticut, Delaware, and Hudson River populations to "threatened," to delist the Kennebec River system population in Maine, and to consider each shortnose sturgeon population as a distinct unit under the ESA definition of species. NMFS received comments on the 1987 review and assembled a second SSRT in 1988 to assess the document and report its findings. However, the team disbanded before completing a report (NMFS 1998).

NMFS convened a third SSRT in 1993, and in 1998 issued a "Final Recovery Plan for the Shortnose Sturgeon: *Acipenser brevirostrum*." The plan recognized 19 distinct population segments (described in Section 3.3 of this report above), and recommended that each should be managed separately for the purposes of the ESA. The decision to treat the populations as distinct was based on biological and ecological differences among them and the lack of recaptures from adjacent river systems. The SSRT considered shortnose sturgeon from different river systems to be "substantially reproductively isolated," and stated that the loss of a single population could risk the permanent loss of unique genetic information that is critical to the survival and recovery of the species. Therefore, in managing the recovery of the species, actions would be evaluated in terms of their potential to jeopardize the continued existence of each distinct population segment, rather than the existence of the species throughout its range (NMFS 1998).

The long-term objective of the NMFS plan is to recover all of the distinct population segments to levels of abundance at which they no longer require protection under the ESA. A population segment could become eligible for downlisting under the plan when it reaches a minimum population size that: (1) is large enough to prevent extinction; and (2) would make loss of genetic diversity unlikely. Determining the thresholds for such a minimum population size was identified as the first priority in the plan. In order to achieve and maintain minimum population size for each population segment, the plan further recognized the need to identify and protect essential habitats, and to monitor and minimize mortality (NMFS 1998).

Within that framework, the plan outlined three specific action steps. The first was to establish listing criteria by determining the size of shortnose sturgeon population segments, as well as evaluating trends in recruitment, determining the minimum habitat for shortnose sturgeon population segments, and determining the maximum allowable mortality for individual population segments. The second action step listed was protection of shortnose sturgeon populations and habitats, through: (1) ensuring agency compliance with the ESA; (2) reducing bycatch; (3) determining if critical habitat designations are prudent for shortnose sturgeon population segments; (4) mitigating/eliminating the impact of adverse human activities on population segments; (5) formulating a public education program to increase awareness of the species and its status; and (6) coordinating federal, state, and private efforts to implement recovery tasks. The third action step in the plan involved rehabilitation of habitats and population segments, including restoring habitats and their functions in the life histories of each population segment, developing a breeding and stocking protocol for shortnose sturgeon, reintroducing the species into river ecosystems where it had been extirpated, and assessing the need to augment population segments through hatchery and stocking programs. The plan went on to list 48 even more specific recovery/research tasks, which were prioritized in an implementation schedule reflecting range-wide and river-specific recovery and research needs (NMFS 1998).

If all recovery criteria are met, the plan envisions that delisting of population segments could begin by 2024. The plan noted that there is evidence some population segments are already starting to recover (for example in the Hudson River). It was also noted, however, that the plan is subject to modifications as may be called for by new findings, changes in species status, and completion of specific tasks described in the plan. In addition, attainment of goals and objectives is contingent upon the priorities of involved federal and state agencies, as well as the availability of funding. Because the shortnose sturgeon inhabits rivers, estuaries, and marine areas along almost the entire east coast, and because there are a myriad of human activities that have the potential to impact the species, a number of agencies are responsible for implementing specific parts of the plan. In addition to NMFS, in recent years these have included agencies in the individual states in which distinct population segments reside, ASMFC, the U.S. Army Corps of Engineers, the Federal Highway Administration, the Environmental Protection Agency, the Federal Energy Regulatory Commission, USFWS, the Nuclear Regulatory Commission, and the National Biological Service (NMFS 1998).

4.4 North American Paddlefish

Paddlefish are not federally listed as threatened or endangered within the United States; the species is believed to be extirpated in Canada (Environment Canada 2001a). However, federal and state biologists have expressed grave concerns regarding the status of the species within portions of its range. There are wide variations among states in the species' legal treatment and regulation of catch. Management regimes concerning paddlefish reflect differing philosophies among regulatory authorities and state legislatures, as well as the fact that the conservation status of the species varies among the numerous states in which it occurs. This becomes clear when examining each state's catch regulations. Some states prohibit all fishing (commercial and sport), while others allow one or both practices but regulate them to various degrees.

The imposition of commercial and sport catch regulations for paddlefish has been fairly recent. Louisiana was the first state to

establish regulations to protect paddlefish. In 1914 the state established a six-month closed season and a 12-inch minimum length to regulate catch. Nearly 25 years elapsed before other state agencies established regulations to protect paddlefish broodstock from commercial overexploitation (Combs 1986). The first record of a paddlefish sport catch regulation found by Combs (1986) was in 1951 for the Osage River, Missouri. In the decades since then, many other states have established restrictions on sport catch to prevent overfishing.

U.S. states within the species' range have made some efforts to coordinate paddlefish (and sturgeon) management. Some inter-jurisdictional research projects and management efforts in the Mississippi Basin have been undertaken under the auspices of MICRA (see Box 4). In other cases, individual states have joined to manage certain paddlefish stocks or fisheries cooperatively (for example, Montana and North Dakota, and Nebraska and South Dakota). Paddlefish range states have also moved to coordinate fishing regulations in common boundary waters, where in the past fishermen from two states may have shared a fishery but been bound by different regulations.

In the Ohio River Basin, recognition that Ohio River paddlefish likely represent a single population, and consideration of the value and vulnerability of paddlefish as a source of caviar, have prompted the development of a comprehensive and coordinated management plan among six states (Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia) to scope a course of action for paddlefish management within the basin. Recommendations in the plan call for states to establish full cooperation in the management and monitoring of paddlefish throughout the Ohio River Basin; continue participation in the MICRA National Paddlefish Study; use Ohio River broodstock in stocking programs to protect the genetic integrity of the population; improve procedures for oversight and assessment of commercial fisheries; align sport catch regulations among states that permit such fisheries; and monitor retail and wholesale prices of caviar and CITES export permits for paddlefish (Henley et al. in press).

Box 4. MICRA

Recognizing the need for improved inter-jurisdictional management of paddlefish and other species in the late 1980s, the 28 states of the Mississippi River Basin created the Mississippi Interstate Cooperative Resource Agreement (MICRA) in the years between 1989 and 1991. Participating states included Alabama, Arkansas, Colorado, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Montana, Nebraska, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Dakota, Tennessee, Texas, Virginia, West Virginia, Wisconsin, and Wyoming.

MICRA developed a comprehensive strategic plan in 1991 in cooperation with the American Fisheries Society and the U.S. Fish and Wildlife Service (USFWS). In 1992, USFWS initiated development of a national framework for the management and conservation of sturgeon and paddlefish species in the United States to better coordinate federal, state, and private efforts and reduce duplicative efforts within USFWS. While MICRA involves species beyond paddlefish and sturgeon, the national framework recognized the importance of MICRA as the mid-continent paddlefish and sturgeon coordination body for the 28 Mississippi River Basin states. MICRA established a Paddlefish/Sturgeon Sub-Committee in the fall of 1992 to address the needs of paddlefish and sturgeon species inhabiting the Basin, and to provide guidance for their future management.

The Subcommittee developed its own Strategic Plan in 1993, with a mission statement to "promote the conservation, management, and enhancement of paddlefish and sturgeon resources in the Mississippi River Basin through improved coordination and communication among responsible

continued on next page

entities." Specific goals included identifying and prioritizing issues and concerns affecting paddlefish and sturgeon resources in the Basin and developing a mechanism to address them; facilitating communication and coordination among entities responsible for paddlefish and sturgeon resource management; developing a Basin-wide information management program based upon standard methods for collecting and reporting fishery resource data; identifying and coordinating paddlefish and sturgeon research, management, culture, and recovery programs; facilitating Basin-wide conservation, protection, and restoration of species' habitats; seeking Basin-wide consensus regarding paddlefish and sturgeon conservation and management through development of uniform, compatible regulations and policies; and increasing the public's awareness of the existence of paddlefish and sturgeon species, appreciation of the ecological and economic importance of these species, and understanding of the environmental and human-related impacts that threaten their welfare and continued existence.

In 1994, MICRA changed its name from "Agreement" to "Association," thus becoming the Mississippi Interstate Cooperative Resource Association. Its greatest challenges have been recurring issues related to the parochial attitudes of some members and to funding. As with any large inter-jurisdictional group, MICRA must constantly face the tendency of some members to think locally rather than Basin-wide. Given that conservation and resource challenges are larger than the state fish and wildlife agencies combined, MICRA needs to continue to focus on the concept that there is strength in numbers and in unity among partners. Unlike the coastal commissions, MICRA receives no federal appropriations and has no real management authority. It is simply a tool, designed and built by and for the states, with federal cooperation, to improve inter-jurisdictional fishery resource management across the Mississippi Basin. Its future relies on the commitment, communication, and cooperation of its members.

Sources: MICRA (1998); Rasmussen (1999).

However, it remains apparent that management strategies for paddlefish continue to differ among states, based on the status of individual state paddlefish populations and the relative priority given to commercial and sport catch, protection, or restoration. Specific regulations pertaining to commercial and sport fishing also differ from state to state, although there have been recent efforts to harmonize regulatory regimes among many states (e.g., the Ohio River management plan). Regulatory tools employed to manage commercial catch, where it is allowed, commonly include gear restrictions, limiting state waters in which catch is allowed, season limits, minimum or maximum size restrictions, and catch reporting requirements. Sport fishing regulations also commonly include gear restrictions, closing certain waters to catch, creel limits and/or catch quotas, season limits, minimum or maximum size restrictions, and reporting requirements. Table 4.4.1 summarizes some of the basic regulatory tools employed by range states to manage paddlefish fisheries.

The following summaries explain in more detail each range state's approach to management of paddlefish, and in particular, rules regarding commercial and sport catch.

Alabama

The paddlefish is protected in the state by Alabama Regulation 220-2-.94: "It is illegal to take or attempt to take paddlefish from all public waters of Alabama by any method or to process paddlefish or any part of a paddlefish. Any paddlefish accidentally captured shall be immediately returned to the waters from whence it came. This regulation does not apply to commercially packaged paddlefish products imported from out-of-state or to paddlefish cultured at hatchery operations or grow out ponds permitted through the Commissioner, Department of Conservation and Natural Resources" (S. Cook, Chief of Fisheries, Alabama Department of Conservation and Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 15, 2000).

Table 4.4.1 Summary of Commercial and Sport Fishing Management Regulations for Paddlefish*

State	Commercial Fishery	Limit/Restrictions	Sport Fishery	Limit/Restrictions
Alabama	No	—	No	—
Arkansas	Yes	G,L,R,S,W	Yes	C,G,W
Illinois	Yes	G,R,W	Yes	C,G,S,W
Indiana	Yes	G,R,W	Yes	C,S
Iowa	No	—	Yes	C,G,W
Kansas	No	—	Yes	C,R,S,W
Kentucky	Yes	G,R,S,W	Yes	C,S,W
Louisiana	No	—	No	—
Minnesota	No	—	No	—
Mississippi	Yes	G,S,W	Yes	G,S
Missouri	Yes	G,L,R,W	Yes	C,G,L,S,W
Montana	No	—	Yes	C,G,Q,S
Nebraska	No	—	Yes	C,G,L,P,S,W
New York	No+	—	No+	—
North Carolina	No+	—	No+	—
North Dakota	No	—	Yes	C,Q,S
Ohio	No	—	Yes	W
Oklahoma	No	—	Yes	C,G,S
Pennsylvania	No+	—	No+	—
South Dakota	No	—	Yes	C,G,L,P,S,W
Tennessee	Yes	G,L,R,S,W	Yes	C,S,W
Texas	No	—	No	—
Virginia	No+	—	No+	—
West Virginia	No	—	No	—
Wisconsin	No	—	No	—

Key: C = Creel limit (sport); G = Gear restrictions; L = Minimum/maximum length restrictions; P = Managed with tag/permit system; Q = Seasonal quota (commercial)/Catch limit (sport); R = Reporting requirement; S = Limited season; W = Waters restricted.

* Sources: Todd (1999); Mosher (1999); State Laws and Regulations (see state-by-state summaries in this section for more information and specific references).

+ Additional Information: **New York**: Natural population extirpated—reintroduction program underway (see Section 6.1 for details). **North Carolina**: Officially listed as endangered based on historical presence and possibility of remnant population; catch prohibited. **Pennsylvania**: Natural population extirpated—reintroduction program underway (see Section 6.1 for details. **Virginia**: Officially listed as threatened based on historical presence and possibility of remnant population; catch prohibited.

Arkansas

Paddlefish are a popular commercial and sport fish in Arkansas. The state defines the species as a game fish, but it can be considered a commercial fish if taken with commercial gear (2000 Arkansas Fishing Regulations). Arkansas regulates its paddlefish fishery through a combination of gear, licensing, reporting, size, season, and closed water restrictions mandated by the Arkansas Game and Fish Commission (AGFC), some of which were instituted beginning in 2002.

Gear restrictions limit Arkansas commercial fishermen to properly licensed drag seines, hoop nets (with or without wings or leads), fiddler nets (without wings or leads) where permitted, slat traps (where permitted), trammel nets, gill nets, limb lines, set lines, trotlines, and snag lines in waters open to commercial fishing. Fishermen must obtain a commercial tackle license for each piece of gear used, and metal tags issued with commercial licenses must be attached to the tackle. The minimum square bar mesh for commercial seine nets, gill nets, and trammel nets is 3-1/2 inches. Additional restrictions or prohibitions regarding the use of certain types of gear also apply in specified state waters (AGFC 2001a).

Commercial fishermen must obtain a current Residential Commercial Fishing Permit and Sportfishing License before operating commercial tackle. In a recent regulatory change, as of 2002 it became illegal for commercial fishermen (or fish farmers) to possess paddlefish, or parts thereof (including roe), without a Resident Roe Taker/Seller Permit, a Resident Roe Taker Helper Permit,[1] a Resident Roe Buyer/Exporter Permit, or a Non-Resident Roe Buyer Permit, as applicable. Specifically, it became illegal to take with commercial tackle, sell, or possess paddlefish or their parts without first obtaining a Resident Roe Taker/Seller Permit, in addition to a commercial fishing license. It became illegal to buy or export paddlefish or their parts across state lines without first obtaining a Resident or Non-Resident Roe Buyer/Exporter Permit. Licensed commercial fishermen who have a Resident Roe Buyer/Exporter Permit may also take paddlefish in accordance with state catch regulations. It remains illegal for fishermen to remove roe from paddlefish while fishing or transporting fish by boat, unless the fishermen have the gutted fish in the boat from which the egg sacks were removed and the eggs remain uncleaned in the egg sacks (AGFC 2001a, 2001b).

Arkansas regulations spell out which state waters are open or closed to commercial fishing. In another regulatory change, as of 2002 commercial fishermen were limited to a statewide paddlefish catch season from December 1 to April 30, except when using sport fishing equipment. The state also opened the Mississippi River, where the paddlefish season had previously been closed from January 1 through April 30 of each year, to catch and roe harvest during the open state season. In a related move, Arkansas acted to increase the minimum length limit for paddlefish to reflect the change in seasons. Effective November 1, 2002, the minimum length limit of paddlefish increased to 32 inches (eye to fork), and to 28 inches blocked-out (head removed behind gills). Prior to that change, commercial fishermen could not take paddlefish smaller than 30 inches (eye to fork) or 24 inches (blocked-out) between November and the end of February, with no length limits imposed during the remainder of the year (AGFC 2001a, 2001b).

Commercial fishing data were not collected from 1982 to 2000 because of a lack of funding and problematic data collection methods (A. Layher, Biologist, Fisheries Division, AGFC, *in litt*. to Teiko Saito, USFWS/OMA, August 18, 2000). Arkansas began collecting data on the harvest of roe in January 2002; the state reported the harvest of 13,361.75 pounds (~6,074 kg; 6.074 metric tons) of paddlefish roe for the year 2002 (pers. comm., B. Posey, Commercial Fishing and Mussel Biologist, AGFC, August, 2002).

Arkansas' daily sport fishing limit is two paddlefish per day in most places, although some counties limit catch to one fish, and also restrict the kind of gear that can be used (AGFC 2000). Catch records are not required or kept for the sport fishery.

Illinois

Illinois considers paddlefish to be both a commercial and sport fish; the means of taking and purposes for which they are taken determine the type of license required (Illinois Department of Natural Resources [DNR] 2001). There are no catch quotas for the commercial catch, but the industry is restricted to portions of the Illinois and Lower Mississippi rivers, and the entire Ohio River (Illinois Administrative Code, Section 830.30). There are no size limits. Commercial fishermen may use trammel nets, gill nets, and seines in waters approved for commercial catch of paddlefish; however, it is illegal to use trammel nets in the Ohio River with less than four-inch bar mesh netting (Illinois Administrative Code, Section 830.40). The state requires commercial fishermen to report the undressed weight of their catch annually, and file a report for activities in the Ohio River by the 10th of each month following catch, whether or not they have taken any fish (Illinois Administrative Code, Section 830.90).

Prior to 1990, there was no requirement for commercial fishermen to report the quantity of eggs taken. The state now requires fishermen to report all roe catch. Initiated by the concern

[1] An Arkansas Roe Taker Helper Permit allows a person to operate the tackle of a licensed commercial fisherman and assist in roe catch when in the immediate presence of a Resident Roe Taker/Seller.

of state fishery managers that paddlefish roe catch may be under-reported, the state conducted a law enforcement activity in the fall of 1999 entitled "Operation True Catch." Under this operation, records from roe buyers were seized and compared to records submitted by commercial fishermen. The concerns expressed by state fishery managers were confirmed when substantial discrepancies were detected through this effort. Harvest reports submitted from 2000 to date are thought to be much more accurate (pers. comm., R. Maher, Illinois Department of Natural Resources, February 2003). Table 4.4.2 shows the commercial paddlefish catch reported for the years 1990 to 2001.

Illinois' sport fishery is limited to a snagging season from September 15 through December 15, and from March 15 through May 15, within 300 yards downstream of all locks and dams of the Illinois and Mississippi rivers in Illinois waters between Illinois and Missouri. Snagging is permitted from January 1 through April 15 within 500 yards of locks and dams on the Mississippi River in Illinois waters between Illinois and Iowa. Fishermen are limited to one pole and line device, to which can be attached no more than two hooks. The sport fishing limit is two per day. All paddlefish that are snagged must be taken into possession and counted into the daily bag limit; no "sorting"—high-grading—is allowed. Once the daily limit is reached, snagging must cease (Illinois Administrative Code, Section 810.20). The state considers this fishery minimal and insignificant, as only one area of the state has consistently proven productive (success is low enough at other dams that few people try). Accurate data on the sport catch are not kept (Mike Conlin, Chief, Division of Fisheries, Illinois Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 23, 2000). No fish, or parts thereof (including eggs), taken by sport fishing methods (including snagging) may be bought, sold, or bartered (Illinois Administrative Code, Section 810.10).

Indiana

Indiana allows both commercial and sport catch of paddlefish. Like Illinois, the state limits waters that can be fished commercially to those of the Ohio River believed by fishery managers to have fairly abundant paddlefish populations. There are few gear restrictions for commercial fishermen; the minimum mesh size is four inches for trammel and gill nets, and one inch for seine and hoop nets. Commercial fishermen targeting paddlefish typically use a five-inch bar mesh (pers. comm., T. Stefanavage, Indiana Department of Natural Resources, February 2002). Catch during the 1990s was estimated at an annual average of approximately 22,389 kilograms. The average harvest of eggs was estimated at

Table 4.4.2 Commercial Paddlefish Catch in Illinois, 1990–2001*

Year	Flesh (pounds)	Eggs (pounds)
1990	75,508	345
1991	57,877	86
1992	46,616	36
1993	43,783	125
1994	56,313	86
1995	48,481	124
1996	64,180	279
1997	49,367	73
1998	44,255	355
1999	64,152	423
2000	36,768	2,292
2001	43,145	607
Total:	**630,445**	**4,831**

* Source: Mike Conlin, Chief, Division of Fisheries, Illinois Department of Natural Resources, *in litt.* to Teiko Saito, USFWS/OMA, August 23, 2000; pers. comm., R. Maher, Illinois Department of Natural Resources, February 2003.

33 kilograms, although that estimate was based on limited information (Todd 1999). Indiana permits a sport snagging fishery for paddlefish during a season from February 1 to May 10, with a catch limit of two fish per day; high-grading is prohibited (Mosher 1999; pers. comm., T. Stefanavage, Indiana Department of Natural Resources, February 2002).

Iowa

Iowa does not permit commercial catch of paddlefish, and prohibits their commercial sale by excluding the species from the approved list of fish whose sale is legal (Iowa Code, Section 482.10). The state allows sport snagging for paddlefish, but restricts the activity. Sport catch of paddlefish is allowed in inland state waters and the Mississippi River year-round. There is a daily catch limit of two, and a possession limit of four (the daily catch limit refers to the number of fish a person may have in a 24-hour period; the possession limit refers to the number of fish a person may have after the first day). There is no minimum length limit. Paddlefish may not be taken in waters of the Missouri and Big Sioux rivers, or in any tributary of those rivers within 200 yards immediately upstream from the confluence. This regulation was put in place during the early 1990s, in concert with similar regulations published by the states of Nebraska and South Dakota, because of concerns about declining paddlefish numbers in the Missouri River system. The state has also designated eight specific areas that are closed to snagging year-round, including sections of the Des Moines River, Cedar River, Iowa River, Charinton River, and the spillway area below the Spirit Lake outlet (Marion Conover, Chief, Fisheries Bureau, Iowa Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 14, 2000; Iowa Fishing Regulations 2002).

Kansas

Kansas does not allow commercial catch of paddlefish. Although paddlefish are present in the Arkansas, Kansas, Marais des Cygnes, Missouri, Neosho, and Verdigris rivers, sport catch is allowed only at the Osawatomie Dam on the Marais des Cygnes River, the Chetopa Dam on the Neosho River, the Tunnel Mill Dam on the Walnut River, and Browning Oxbow Lake that adjoins the Missouri River (Tom Mosher, Fisheries Research Coordinator, Kansas Department of Wildlife and Parks [KDWP], *in litt*. to Teiko Saito, USFWS/OMA, August 17, 2000; pers. comm., T. Mosher, KDWP, September 2002).

The creel limit in the sport fishery is two fish per day, with a possession limit of six. The season lasts from March 15 to May 15 (Mosher 1999). Except at Osawatomie Dam, each paddlefish caught is included in the creel and possession limit, and each fisherman is required to keep all paddlefish caught on a stringer, cord, cable, or chain in a basket, sack, cage, or other holding device. At Osawatomie Dam, paddlefish must be 34 inches eye to fork of tail to be legal. Furthermore, fishermen must check their catch at a state check station immediately upon reaching the creel limit or completing the day's fishing. Each checked paddlefish is tagged with a numbered tag attached to the lower jaw; fishermen must provide their name, address, and fishing license number at the check station (Kansas Paddlefish Regulations, Section 115-7-1). Catch levels from 1992 to 2002 at Osawatomie Dam and Chetopa Dam are summarized below in Table 4.4.3.

Past creel surveys estimated approximately 2,200 to 4,300 angler days during various yearly seasons at Chetopa Dam, drawing anglers from other communities and contributing to the economy of small Kansas towns. Angler days were probably much higher in 1999, when more than 2,000 fish were taken (Tom Mosher, Fisheries Research Coordinator, KDWP, *in litt*. to Teiko Saito, USFWS/OMA, August 17, 2000). Stocking efforts during the 1990s played a significant role in supporting these fisheries. The state's program is discussed in Section VI on Hatcheries and Commercial Aquaculture.

Kentucky

Kentucky permits both commercial and sport catch of paddlefish, and regulates both practices. The state limits which waters commercial fishermen may use, and allows use of commercial gear in other waters only under special permit. This is done through the

Table 4.4.3 Recorded Angler-Caught Paddlefish at Osawatomie Dam and Chetopa Dam, Kansas, 1992–2002*

Year	Chetopa Dam (# of Paddlefish Caught)	Osawatomie Dam (# of Paddlefish Caught)
1992	71	4
1993	541	87
1994	325	19
1995	769	12
1996	479	11
1997	394	75
1998	800	58
1999	2,010	457
2000	98	5
2001	38	0
2002	481	19

* Sources: Tom Mosher, Fisheries Research Coordinator, KDWP, *in litt.* to Teiko Saito, USFWS/OMA, August 17, 2000; pers. comm., T. Mosher, KDWP, Sept. 2002.

Department of Wildlife Resources' statutory authority under 301 KAR 1:150, "Waters Open to Commercial Fishing." The regulation spells out specific streams and rivers (or parts thereof), and lakes (or parts thereof), that are open to commercial fishing. These bodies of water can be opened and closed by state fisheries managers as they deem necessary to conserve the resource base or to respond to conditions. Further, the state regulates the types of devices that commercial fishermen may use and where in specific water bodies they can and cannot be deployed (301 KAR 1:155, "Commercial Fishing Requirements"). Finally, the state requires commercial fishermen using nets to acquire a special permit and limits the size of gill nets (KAR 1:140, "Special Commercial Fishing Permit"). Table 4.4.4 shows the catch of paddlefish for the years 1999 to 2002 (partial total for 2002) in Kentucky waters open to commercial fishing. As the figures in the table show, the Ohio River is by far the most heavily fished river in Kentucky, providing the vast majority of both paddlefish flesh and roe. The increase in reported catch from 1999 to 2000 and

Table 4.4.4 Commercial Catch of Paddlefish in Kentucky Waters, 1999–2002 (partial)*

	1999+		2000		2001		2002++	
Water Body	Flesh (lbs)	Eggs (lbs)	Flesh (lbs)	Eggs (lbs)	Flesh (lbs)	Eggs (lbs)	Flesh (lbs)	Eggs (lbs)
Barkley Lake	23,178	32	16,123	22	23,083	3	19,462	62
Cumberland Lake	1,185	—	2,012	60	4,534	82	2,895	—
Cumberland River	127	—	198	4	3,061	200	1,450	7
Green River	—	—	60	—	4	—	138	—
Kentucky Lake	10,045	16	8,294	34	3,797	17	8,577	61
Kentucky River	3,101	446	1,876	307	2,205	243	314	35
Mississippi River	632	4	14,940	3,817	4,756	1,321	3,140	201
Ohio River	135,350	6,665	302,045	15,935	507,025	19,196	340,236	14,783
Tennessee River	696	2	1,053	—	617	2	445	14
Pond River	—	—	50	—	—	—	10	—
Rough River	—	—	12	—	—	—	—	—
Total:	***174,314***	***7,165***	***346,663***	***20,179***	***549,082***	***21,064***	***376,667***	***15,163***

* Source: Kentucky Department of Fish and Wildlife Resources.

\+ Harvest totals for each license year March 1 through February 28.

++ Harvest totals for March 1, 2002 through November 30, 2002.

beyond may have been influenced by increased demand for paddlefish caviar; however, it should be noted that 1999 was the first year that fishermen were required to report their catch, and initial compliance is believed to have been low (pers. comm., D. Henley, Kentucky Department of Fish and Wildlife Resources, December 2002).

Kentucky permits sport fishing (snagging) for paddlefish statewide from February 1 to May 10 except in locations listed in 301 KAR 1:075, "Gigging, grabbing or snagging, tickling and noodling." The exception is the Tennessee River below Kentucky Lake Dam, which is open year-round and has a daily limit of 15 fish. The Ohio River and remaining areas open to snagging have no creel limits during the snagging season (pers. comm., D. Henley, Kentucky Department of Fish and Wildlife Resources, December 2002).

Louisiana

Paddlefish have been a protected species in Louisiana since 1986, and there has been no commercial or sport fishing for the species since that year. Under state law, it is illegal to possess paddlefish, sturgeon, or their parts (including roe). Violators face a maximum fine of $2,500 per violation (J. Roussel, Assistant Secretary, Office of Fisheries, Louisiana Department of Wildlife and Fisheries, *in litt*. to Teiko Saito, USFWS/OMA, August 25, 2000).

Minnesota

Minnesota does not allow commercial or recreational catch of paddlefish. The species is not common in the state, and is believed to have disappeared from many Minnesota waters. Under MN Statute 97C.411, paddlefish, lake sturgeon, and shovelnose sturgeon may not be taken, bought, sold, transported or possessed except as provided by a rule from the Minnesota Commissioner of Natural Resources. The Commissioner may only allow the taking of these fish in waters that the state boundary passes through, and in tributaries to the St. Croix River. Any such action to open a season for paddlefish appears unlikely in the near future (Linda Erickson-Eastwood, Fisheries Program Manager, Minnesota Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 23, 2000).

Mississippi

Mississippi allows commercial catch of paddlefish, which are classified in Section 49-7-1 of the Mississippi Code of 1972 [the Code] as "nongame gross fish." However, the commercial fishing season is closed from November 1 to April 30 of each year. Because the timing of the seasonal closure coincides with the paddlefish spawning season, paddlefish roe is not harvested in Mississippi, and the state does not keep catch records. During the closed season it is illegal to fish for, take, or have in possession paddlefish or their parts, including eggs (roe) (Mississippi Department of Wildlife, Fisheries and Parks [MDWFP] 2000b). Section 49-7-90 of the Code further stipulates that any person who takes or possesses a paddlefish in violation of the law or who commits waste by discarding any parts of a paddlefish into state waters may be guilty of a Class I violation. Section 49-7-141 of the Code specifies that the penalty for such a violation is a fine of $2,000–$5,000, five days in county jail, and forfeiture of all hunting, trapping, and fishing privileges for a period of not less than 12 months. It is also illegal to sell any non-game gross fish without a valid freshwater commercial fishing license ($30 for residents; $200 for nonresidents).

In addition to restricting the legal fishing season, Mississippi restricts the types of gear that commercial fishermen may use to catch paddlefish and other nongame gross fish (e.g., seine nets are banned; trotlines, snag lines, hoop nets, barrel nets, trammel nets, and gill nets are restricted in size and use). Commercial fishermen must purchase a $3 equipment tag for each piece of gear. The state has also closed certain state waters to all types of freshwater commercial fishing gear, and in other state waters specifically restricts the types of gear allowed. Mississippi has not established minimum or maximum size restrictions for paddlefish (MDWFP 2000b).

The state also allows a two-month sport snagging season in October and November of each year, with a creel limit of two fish per day. Sport fishermen are restricted to the use of legal commercial gear (pers. comm., D. Riecke, MDWFP, September 2002).

Missouri

Missouri allows commercial catch of paddlefish in the Mississippi River, with restrictions. Commercial fishermen must obtain a permit that costs $25 for residents and $200 for non-residents. In addition, each permittee must tag each net, seine, or group of 50 hooks for juglines, trotlines, bank lines, limb lines, or throwlines under a set fee schedule. These tags are not transferable and tagged equipment must be attended personally by the permittee or by another licensed commercial fisherman authorized in writing by the permittee as an assistant. A licensed commercial fisherman must be present in each boat (Wildlife Code of Missouri, 3CSR10-10.720).

There are no catch quotas for paddlefish. There are, however, restrictions on what state waters may be fished, size limits, and gear restrictions. Paddlefish cannot be taken commercially on the Missouri River or on that part of the Saint Francis River that forms the boundary between Arkansas and Missouri. In the Mississippi River fishery, the minimum length limit is 24 inches, measured from eye to fork of tail, and the head and tail must remain attached to the fish while on commercial waters. Commercial fishing gear cannot be used or set within 300 yards of any spillway, lock, dam, or the mouth of any tributary stream or ditch. In addition, the minimum bar measure for seines, gill nets, and trammel nets is two inches (when wet); the minimum bar measure for hoop nets and wings is 1-1/2 inches (when wet); and hooks attached to trotlines or throwlines must be at least two feet apart (Wildlife Code of Missouri, 3CSR10-10.725).

All commercial fishermen must submit a monthly report on a form provided by the Department of Conservation, showing the place of origin and the quantity and species of fish taken during the preceding month. The form must be filed even if no fish are taken, and permit renewal is conditional on receipt by the Department of Conservation of satisfactory monthly reports (Wildlife Code of Missouri, 3CSR10-10.727). Table 4.4.5 shows Missouri paddlefish catches from 1992 to 2001. The state has not monitored the harvest of roe, so data are available only on the total pounds caught.

Missouri also permits sport fishing for paddlefish from March 15 through April 30, except on the Mississippi River, where the season is March 15 through May 15 and September 15 through December 15. The daily creel limit is two fish. Permitted fishing methods include pole and line, snagging, grabbing, trotline, throwline, limb line, bank line, jug line, and falconry. The minimum length limit is 24 inches, measured from the eye to the fork of the tail. On Lake of the Ozarks and its tributaries, Table Rock Lake and its tributaries, and Truman Lake and its tributaries, the minimum length is 34 inches. Paddlefish eggs from sport fishing may not be

Table 4.4.5 Missouri Commercial Paddlefish Catch, Mississippi River, 1992–2001*

Year	Catch (lbs)
1992	5,520
1993	2,324
1994	9,729
1995	6,418
1996	4,483
1997	8,285
1998	5,167
1999	8,675
2000	13,481
2001	18,732

* Source: Kim Graham, Missouri Department of Conservation, *in litt.* to USFWS/OMA, August 2000; pers. comm., V. Travnichek, Missouri Department of Conservation, February 2003.

bought, sold, offered for sale, or transported, and paddlefish or parts thereof (including eggs) cannot be used for bait. In addition, paddlefish may not be taken from restricted zones listed by the state as closed to fishing and snagging, or possessed on certain waters designated by the state (Wildlife Code of Missouri, Section 3CSR10-6.525).

Montana

Paddlefish are classified as a game fish in Montana. The state allows snag fishing for the species and the sale of paddlefish roe as caviar. Commercial fishing is not permitted, but Montana's paddlefish management program (along with North Dakota's) includes a roe donation program that sells caviar harvested from sport fishing through a nonprofit corporation.

General regulations that apply to catch of paddlefish in all Montana waters include a requirement that every angler, regardless of age, must purchase a proper conservation license, fishing license, and paddlefish tags, which must be in the angler's immediate possession while fishing. Each angler must also cast for, hook, and reel in his or her own paddlefish; it is illegal for another person to do so. Anglers must immediately tag paddlefish with their own tag; any tag locked shut prior to attachment, or any altered or modified tag, shall be voided. If an angler cuts up a paddlefish, he/she must keep the part of the back and dorsal fin to which the tag is attached and sealed to the fish; tags must remain with the processed fish until consumption (Montana Eastern Fishing District Special Regulations, 2000).

Other Montana catch regulations for paddlefish differ according to water body. In the Missouri River upstream from Fort Peck Dam, the state allows a year-round season with a limit of two paddlefish per season. Downstream from Fort Peck Dam, the Missouri River paddlefish fishery is managed in conjunction with North Dakota. In 1994, Montana and North Dakota instituted the Yellowstone-Sakakawea Paddlefish Management Plan, which established goals and objectives for a sustainable recreational catch consistent with the productive capacity of the stock. In recent years, the agreement established a maximum harvest of 1,500 paddlefish taken per state per year; however, in late 2002 North Dakota and Montana anticipated adopting a recommendation to lower the harvest cap to 1,000 fish per state per year, based on evidence of a slow decline in the overall estimated stock of 30,000 adult paddlefish (see also summary for North Dakota below). In this fishery, Montana regulations allow a maximum annual catch of one paddlefish per season, and the Montana Department of Fish, Wildlife and Parks may close the season with 48 hours notice in any year in which it appears that the harvest cap may be significantly exceeded. In addition to snagging, paddlefish may be harvested using hook and line and/or bow and arrow in the Fort Peck Dredge Cuts (Montana Eastern Fishing District Special Regulations, 2000). There is also a limited, one paddlefish per season fishery on the Yellowstone River (this fishery allows catch-and-release only on Wednesdays and Sundays between 3 p.m. and 9 p.m.) (L. Peterman, Administrator, Fisheries Division, Montana Fish, Wildlife and Parks, *in litt*. to Teiko Saito, USFWS/OMA, August 21, 2000).

Table 4.4.6 summarizes the estimated annual catch of paddlefish in Montana from 1992 through 2002.

A 1997 survey of paddlefish anglers reported that 73% favored catch-and-release opportunities, and that an estimated 3,000 anglers snagged for paddlefish annually. Based on a 1993 survey, approximately 35% of anglers in Montana were non-residents. Few anglers were motivated to snag a paddlefish to obtain eggs for caviar (L. Peterman, Administrator, Fisheries Division, Montana Fish, Wildlife and Parks, *in litt*. to Teiko Saito, USFWS/OMA, August 21, 2000).

An unusual feature of Montana's program is the paddlefish roe donation program, which was established through a Memorandum of Understanding between the state and the Glendive Area Chamber of Commerce and Agriculture. Under this program, a nonprofit corporation was established to take donations of eggs from recreational fishermen. The eggs are then processed and sold, and by law 40 percent of the proceeds are applied toward paddlefish management programs (Montana Fish and Wildlife Statutes, 87-4-601[d][i]). During the 1990s, annual roe production averaged 3,337.66 pounds; the average gross

Table 4.4.6 Paddlefish Catch Data in Montana, 1992–2002*

Year	# of Paddlefish Caught
1992	1,016
1993	2,746
1994	1,031
1995	2,543
1996	1,942
1997	1,575
1998	967
1999	1,986
2000	666
2001	360
2002	682

* Source: Larry Peterman, Administrator, Fisheries Division, Montana Fish, Wildlife and Parks, *in litt.* to Teiko Saito, USFWS/OMA, August 21, 2000; pers. comm, K. McDonald, Montana Department of Fish, Wildlife, & Parks, September 2002.

annual income of the venture was $138,488 over the same period. The Montana roe donation program, and a companion program underway in North Dakota, are the only ones of this type in the United States, and Montana's has become increasingly important to the Glendive Chamber of Commerce (L. Peterman, Administrator, Fisheries Division, Montana Fish, Wildlife and Parks, *in litt*. to Teiko Saito, USFWS/OMA, August 21, 2000).

Nebraska/South Dakota

Neither Nebraska nor South Dakota allows commercial catch of paddlefish, but the two states jointly manage a sport fishery and so are combined here. Paddlefish are classified as a sport fish in both states. There are two controlled seasons—an archery season during 16 days in the middle of July and a 30-day snagging season in October. These are on the Missouri River below Gavins Point Dam along the two states' common boundary. Table 4.4.7 shows the sport catch from the snagging season for 1992 to 2002, along with the management strategy for the fishery.

As Table 4.4.7 shows, from 1992 through 1996 the season was managed by a quota system that allowed for a 30-day season or a catch of 1,600 fish, whichever came first. During this period, the catch quota was reached in six days or fewer in two out of the five years. Beginning in 1997, management of the paddlefish catch switched to a tag/permit system. Between 1997 and 1999, the two states issued a total of 2,250 tags per year. Beginning in 2000 the number of tags issued was increased to 2,800 per year

Table 4.4.7 Sport Catch from South Dakota/Nebraska Snagging, 1992–2002*

Year	# of Paddlefish Caught	Management
1992	1,000	Managed with 1,600 fish quota
1993	1,529	Managed with 1,600 fish quota
1994	1,568	Managed with 1,600 fish quota
1995	2,200	Managed with 1,600 fish quota
1996	1,828	Managed with 1,600 fish quota
1997	948	Managed with tag/permit system
1998	1,125	Managed with tag/permit system
1999	1,334	Managed with tag/permit system
2000	943	Managed with tag/permit system
2001	1,030	Managed with tag/permit system
2002	732	Managed with tag/permit system

* Source: Clifton Stone, Senior Wildlife Biologist, Reservoir Fisheries, South Dakota Department of Game, Fish and Parks, *in litt.* to Rosemarie Gnam, USFWS/OMA, August 25, 2000; pers. comm, C. Stone, January 2003.

(1,400 per state). The snag fishery is also managed with a protected slot limit of 35 to 45 inches from the eye to the fork of the tail (i.e., anglers have to release any paddlefish that measures from 35- to 45-inches from the eye to the fork of the tail). Snagging is allowed from 7:00 a.m. to 7:00 p.m. daily (Clifton Stone, Senior Wildlife Biologist, Reservoir Fisheries, South Dakota Department of Game, Fish and Parks, *in litt*. to Rosemarie Gnam, USFWS/OMA, August 25, 2000; pers. comm, C. Stone, South Dakota Department of Game, Fish and Parks, January 2003).

Along with the snag fishery, Nebraska and South Dakota estimate that another 100–150 paddlefish are harvested annually during a July archery season. During this season paddlefish archery anglers can fish from sunrise to sunset (Clifton Stone, Senior Wildlife Biologist, Reservoir Fisheries, South Dakota Department of Game, Fish and Parks, *in litt*. to Rosemarie Gnam, USFWS/OMA, August 25, 2000). The tag quota for the archery season is a maximum of 550 tags (275 per state) (pers. comm., C. Stone, South Dakota Department of Game, Fish and Parks, January 2003).

New York

Paddlefish were historically present in the Allegheny River in southwestern New York, but were extirpated by the early 1900s. As of 2000, the species had no official status or special protection in the state. As is detailed in Section VI on Hatcheries and Commercial Aquaculture, in 1998 New York initiated a restoration plan through stocking. Should the program show a meaningful rate of survival, the state anticipated possible action to prohibit harvest in 2002 (P. Festa, New York State Department of Environmental Conservation, in. litt. to Teiko Saito, USFWS/OMA, August 22, 2000).

North Dakota

With Montana, North Dakota manages the paddlefish as a game species under the Yellowstone-Sakakawea Paddlefish Management Plan. In recent years there has been a harvest cap of 1,500 paddlefish taken per state per year; however, in late 2002 North Dakota and Montana were expected to adopt a recommendation to lower the harvest cap to 1,000 fish per year, based on evidence of a slow decline in the overall estimated stock of 30,000 adult paddlefish. The paddlefish season runs May 1–31, unless there is an in-season closure (as was the case in 2001 and 2002). Only snagging is permitted; there is no catch-and-release (pers. comm., G. Power, North Dakota Game and Fish Department, September 2002). Table 4.4.8 shows the annual paddlefish catch from 1995 to 2002.

The state has an MOU in place with a nonprofit corporation, North Star Caviar, to process and sell eggs, with 25% of the net proceeds reverting to research and management of stocks (G. Power, Fisheries Division, North Dakota Game and Fish Department, *in litt*. to Teiko Saito, USFWS/OMA, August 22, 2000). Table 4.4.9 shows annual paddlefish/roe donation and caviar production from North Star Caviar for the years 1993–2002.

Table 4.4.8 North Dakota Paddlefish Catch, 1995-2002*

Year	# of Paddlefish Caught
1995	1,724
1996	975
1997	800
1998	1,970
1999	1,309
2000	2,205
2001	1,566
2002	1,364
Average:	***1,489***

* Sources: G. Power, Fisheries Division, North Dakota Game and Fish Department, *in litt.* to Teiko Saito, USFWS/OMA, August 22, 2000; pers. comm., G. Power, North Dakota Game and Fish Department, September 2002.

Table 4.4.9 Annual Paddlefish/Roe Donation and Caviar Production, North Star Caviar, 1993–2002*

Total	Total Males	Total Females	70+ lb Females	Total Fish	Green Eggs (lbs)	Total Caviar (lbs)
1993	596	541	222	1,137	5,820	3,710
1994	377	480	221	857	4,917	2,274
1995	587	564	282	1,151	6,538	3,958
1996	307	339	172	646	3,589	2,290
1997	320	301	139	621	3,388	1,659
1998	745	708	345	1,453	9,098	4,026
1999	498	449	218	947	5,901	2,640
2000	805	739	366	1,544	8,454	3,052
2001	801	603	284	1,404	7,132	2,935
2002	853	449	193	1,302	5,342	3,466
Totals	***5,889***	***5,173***	***2,442***	***11,062***	***60,179***	***30,010***
Averages	***589***	***517***	***244***	***1,106***	***6,018***	***3,001***

* Source: pers. comm., G. Power, North Dakota Game and Fish Department, September 2002.

Ohio

Ohio's paddlefish population is limited in distribution and relatively rare. Paddlefish were listed as an endangered species in Ohio from 1974 until 1987, when the species was relisted as threatened, a status that does not automatically bar all fishing. There is no commercial fishery in Ohio, however, and recreational anglers cannot take paddlefish within 1,000 feet downstream of four large dams in the state (G. Isbell, Executive Administrator, Fish Management and Research, Ohio Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 15, 2000).

Oklahoma

Oklahoma does not permit commercial fishing for paddlefish. The state allows a sport catch, with restrictions. There are three seasons. The first is from January 1 to March 14, when the creel limit is one fish per day, and catch-and-release is permitted by use of rod and reel and trotline only. The second, from March 15 through May 15, has a creel limit of three fish per day. During this season catch-and-release fishermen may use any method except a trotline, other fishermen may keep what they catch to the daily limit of three and then cease fishing, and trotliners may keep all fish until reaching the daily limit of three, then release all others immediately. The third season, from May 16 through December 31, reverts to a catch limit of one per day, with catch-and-release fishing restricted to use of rod and reel and trotlines. This fishery is believed to be important to the state because of the high number of participating fishermen from in-state and out-of-state (Kim E. Erickson, Chief, Fisheries Division, Oklahoma Department of Wildlife Conservation, *in litt*. to Teiko Saito, USFWS/OMA, August 28, 2000; Oklahoma 2002 Fishing Guide).

Other special regulations in the state include a prohibition on culling (i.e., high-grading), and a requirement that persons in possession of paddlefish keep their catch separate and distinctly identifiable from others' (plainly labeled with taker's name and address). No person may possess 50 or more pounds of raw, unprocessed, and frozen paddlefish eggs, or five pounds or more of processed paddlefish eggs. Also, no person may ship into or out of, transport into or out of, have in possession with the intent to so transport, or cause to be removed from the state raw unprocessed or processed paddlefish eggs, unless they are in a solid, frozen state (Kim E. Erickson, Chief, Fisheries Division, Oklahoma Department of Wildlife Conservation, *in litt*. to Teiko Saito, USFWS/OMA, August 28, 2000; Oklahoma 2002 Fishing Guide).

Another aspect of Oklahoma's management efforts is a program to reintroduce paddlefish

to state waters. This program is discussed in Section VI under Hatcheries and Commercial Aquaculture.

Pennsylvania

While natural paddlefish populations are believed to have been extirpated in Pennsylvania, the state is engaged in a long-term restoration effort in the major rivers in the west of the state, primarily the Allegheny and Ohio. The effort centers on stocking fingerlings to establish a spawning population that can then be managed on a self-sustaining basis. The effort has been ongoing for long enough that it is possible that individuals of one year-class have reached sexual maturity. These may not be taken by commercial or sport fishermen. The prohibition on catch will continue until assessment work is done to determine the existence and extent of natural reproduction (Richard Snyder, Chief, Division of Fisheries Management, Pennsylvania Fish and Boat Commission, *in litt*. to Teiko Saito, USFWS/OMA, August 15, 2000). Pennsylvania's paddlefish restoration program is described in greater detail in Section VI on Hatcheries and Commercial Aquaculture.

Tennessee

Tennessee allows commercial catch of paddlefish, and closely regulates the practice. The Tennessee Wildlife Resources Agency's (TWRA) management of commercial fisheries has changed significantly over the past decade. Prior to 1993, there were no special regulations regarding paddlefish. Then, from 1993 to 1998, the state closed the commercial catch season from February 16 through April 15, and banned possession of paddlefish during that time unless they were taken legally prior to the season closure. Wholesale fish dealers importing paddlefish flesh or eggs into the state during the closed season were required to have bills of lading denoting pounds of flesh or eggs, name of supplier, supplier's address, and date of import (TWRA 2000).

In 1998 and 1999, commercial fishermen were required to obtain a free Paddlefish Permit from TWRA to catch paddlefish in state waters, which could be obtained by written request. Sequentially numbered tags, which fishermen had to secure to caught paddlefish, were issued to Permit holders, and the closed season was modified to include February 16 through April 14 and May 1 through October 31. A minimum length requirement of 30 inches (eye to fork) was introduced, and commercial fishermen had to tag paddlefish as instructed by the state and provide requested information and lower jaw samples to TWRA. The tag had to remain on the paddlefish until the fish reached the final stage of processing, and fishermen marketing out of state had to provide TWRA with requested information on forms provided. Wholesale fish dealers importing paddlefish or parts thereof during the closed season had to have bills of lading denoting pounds of flesh or eggs, name of supplier, supplier's address, and date of import. Those purchasing paddlefish or eggs had to provide requested information and sometimes roe samples to TWRA (TWRA 2000).

Since 1999, commercial fishermen have been required to obtain a free Paddlefish Permit from TWRA prior to taking paddlefish from state waters, in addition to purchasing either a $125 Resident Commercial Fishing License (Resident "Helpers"—anyone assisting the fisherman in the boat—must also purchase a $125 license) or a $500 Nonresident Commercial Fishing License (Nonresident "Helpers" must also purchase a $500 license). Such permits can be obtained by written request. The closed season was further modified in 1999 to include the period from April 24 through October 31, with possession being illegal during closed season unless the paddlefish was previously taken during the legal season. Those persons in possession of paddlefish during the closed season must also have in their possession bills of lading denoting pounds of flesh or eggs (or both), name and address of supplier/fisherman, and date of catch or date obtained. The minimum length limit was increased to 32 inches eye to fork, or if blocked (with the tail still on the fish), to a minimum of 24 inches from the fork of the tail to the flesh behind the gill arch (measured along the side of the fish) (TWRA 2000).

Tennessee commercial fishing regulations for 2003–2004 contain some further modifications. The closed season now includes the period from April 24 to November 14. The minimum length limit is 34 inches eye to fork, or 25 inches from the fork of the tail to the flesh behind the gill arch if blocked (measured along

the side of the fish). Paddlefish less than 34 inches must be returned immediately to the water, and paddlefish larger than 34 inches may not be possessed alive away from the waters where they were caught (TWRA 2003).

For 2003–2004, a 2-inch portion of ovary must remain in each paddlefish caught while on the water or immediately adjacent to the water where it was taken. Any paddlefish and/or shovelnose sturgeon from which eggs are taken must be kept. The cutting or mutilation of paddlefish or shovelnose sturgeon to check for eggs is prohibited. Paddlefish eggs removed from ovaries must be kept in separate containers—eggs from only one fish per container. Paddlefish may not be kept alive except for approved aquaculture purposes. For species management purposes, TWRA may require paddlefish and/or sturgeon permit holders to affix sequentially numbered tags to paddlefish and sturgeon caught. Commercial fishermen harvesting paddlefish or parts thereof from the state's waters must tag paddlefish as instructed by TWRA and provide requested information and samples to TWRA. Tags, when required, must remain on the paddlefish and sturgeon until the fish is in the final stage of processing (TWRA 2003).

Paddlefish and sturgeon or parts thereof taken from state waters and sold in-state must be marketed to a licensed wholesale fish dealer. Commercial fishermen and wholesale fish dealers are required to submit reports to TWRA on forms provided. Commercial fishermen marketing outside of Tennessee must provide TWRA with a commercial fish export form and any additional requested information on forms provided by TWRA; copies of the export form must be submitted to TWRA monthly. Prior to sale to an in-state wholesale fish dealer or being marketed outside of Tennessee, paddlefish and shovelnose sturgeon carcasses may not be altered in a manner that the length of the fish cannot be determined (TWRA 2003).

Wholesale fish dealers, private individuals, and businesses importing paddlefish and sturgeon or parts thereof must have bills of lading denoting pounds of flesh or eggs (both if applicable), name and address of supplier, and date of import. Wholesale fish dealers, private individuals, and businesses importing or purchasing paddlefish and/or eggs for commercial purposes must issue a commercial fish receipt to the commercial fishermen and provide requested information and samples to TWRA. Wholesale fish dealers must submit copies of the receipts to TWRA monthly, and are further required to maintain sale records, including receipts, available for audit. These records must contain the quantity of fish or eggs sold and the buyer's address, including city, state, and country (TWRA 2003).

In addition to those regulations, Tennessee restricts the number of state waters open to commercial fishing, and restricts the type and size of gear (nets) that may be used in commercial catch. The number and percentage of state waters closed to commercial fishing has been a point of frustration for many Tennessee commercial fishermen (TRAFFIC interviews with Tennessee commercial fishermen, 2001). In November 2002, Guntersville Reservoir was reopened to the commercial harvest of paddlefish. Table 4.4.10 shows the commercial catch of paddlefish in Tennessee from 1990 to 2001 (data for 2001 are preliminary).

Along with commercial catch, Tennessee permits sport fishing for paddlefish, limited to a season from March 1 through March 15 on the Cherokee Reservoir. The daily creel limit is one fish, and any paddlefish taken or parts thereof may not be sold. Prior to the current sport fishing regulation, a two-year moratorium on sport fishing had been imposed to allow time for law enforcement to investigate and correct paddlefish violations. In the past several years the sport catch of paddlefish has been negligible, with no noticeable impact on the population (Robert Todd, Commercial Fishing Coordinator, Tennessee Wildlife Resources Agency, *in litt*. to Teiko Saito, USFWS/OMA, August 21, 2001).

Texas

Texas, which considers the paddlefish as threatened under state law, has protected the species since 1977. No catch or trade is permitted. Historically, paddlefish inhabited the Red River's tributaries, including the Sulphur River, Big Cypress Bayou, the Sabine River, the Neches River, the Angelina River, the Trinity River, and the San Jacinto River. The Texas Department of Wildlife and Parks

Table 4.4.10 Estimated Paddlefish Catch/Egg Harvest in Tennessee, 1990–2001*

Year	Paddlefish Catch/Flesh (lbs)	Egg Harvest (lbs)
1990	486,444	—+
1991	104,997	—+
1992	133,253	187
1993	118,793	1,597
1994	130,551	1,247
1995	125,882	1,506
1996	64,852	140
1997	89,292	626
1998	53,426	1,886
1999	54,892	3,096
2000	192,644	26,354
2001++	185,816	21,092

* Source: TWRA (2001); pers. comm., R. Todd, TWRA, February 2003.

\+ 1990–1991 commercial fishing surveys did not request catch information regarding eggs.

++ Preliminary estimate.

undertook a significant restoration effort by stocking paddlefish from 1989 to 2000 (Texas Department of Wildlife and Parks 2002a, 2002b). This program is discussed in more detail in Section VI on Hatcheries and Commercial Aquaculture.

West Virginia

The paddlefish is on West Virginia's Rare Species List, with very few believed to exist in the state. Catch or possession is prohibited, and any fish caught must be returned to the water immediately (West Virginia Fishing Regulations 2001). As is discussed in more detail in Section VI on Hatcheries and Commercial Aquaculture, the state has stocked paddlefish for several years in an effort to recover the population.

Wisconsin

The paddlefish is classified as a threatened species in Wisconsin. Catch or possession of the species is prohibited (Karl Scheidegger, Wisconsin Department of Natural Resources, *in litt.* to Rosemarie Gnam, USFWS/OMA, August 17, 2000).

4.5 Shovelnose Sturgeon

The shovelnose sturgeon is indigenous to the United States, and has not been designated as threatened or endangered by the federal government. In the past, management of shovelnose sturgeon catch by state authorities has often been less carefully monitored and regulated than has catch of paddlefish in jurisdictions where it is allowed, primarily because the species has typically been looked upon as fairly common in many states. Also, the shovelnose sturgeon has only recently become particularly valuable for the commercial trade, given its small size and low yield of roe per fish.

TRAFFIC's research for this report raised several points of concern that might indicate that closer attention needs to be paid to the possible impact of commercial or sport catch of shovelnose sturgeon in the future. First, the lack of comprehensive data on past shovelnose catch levels means that there is no baseline against which to compare current catch rates. Furthermore, some states that allow commercial fishing initiated regulations to monitor the catch only recently. That the shovelnose sturgeon has received comparably less attention than other acipenseriform species might not pose a problem as long as the species remains of secondary commercial interest. Yet in the event of a collapse in Caspian Sea sturgeon stocks, shovelnose sturgeon, like other North American species, could generate much more interest as a possible substitute source of caviar, and any lack of effective monitoring and regulation could prove costly.

Second, the fact that the shovelnose sturgeon is a small, low-yielding species could work against it if fishing pressure intensifies. Informal estimates indicate that it requires five to six shovelnose sturgeon to produce the equivalent amount of roe that can be harvested from a single gravid paddlefish (pers. comm., interviews with Tennessee commercial fishermen, 2001). This means that generating sufficient roe to sustain a profitable commercial fishery requires the taking of several times more shovelnose sturgeon than paddlefish or other, larger sturgeon species.

Third, the fact that the shovelnose sturgeon is now cut off from historical spawning rivers and habitat in several states and river systems or has had its habitat degraded has led to the species' being considered "locally abundant" in only about 75% of its historic range (NPSSC 1993; Hesse and Carreiro 1997). Thus, the impact of increased commercial fishing would likely be concentrated in certain areas and populations. Because the actual abundance of the species has not been closely documented and a sustainable rate of catch has not been definitively calculated, TRAFFIC is concerned that sharply intensified pressure on the species could result in the kind of population declines seen in other North American sturgeon fisheries in the past.

The following summaries explain in more detail the different approaches to management and catch in those states with extant (and in some cases possible) shovelnose sturgeon populations.

Alabama

As noted in section 3.5, the status of the shovelnose sturgeon in Alabama is uncertain. However, regarding catch, Alabama closed its waters to all catch of any sturgeon species in 1972 (USFWS/GSMFC 1995).

Arkansas

Arkansas permits commercial and recreational fishing for shovelnose sturgeon. Commercial fishing regulations regarding gear restrictions are the same as those required for paddlefish that were detailed in Section 4.4 (e.g., commercial fishermen may use only properly licensed and approved equipment; prohibitions regarding the use of certain types of gear apply in specified state waters; etc.). Also, as with paddlefish, commercial fishermen must obtain a Residential Commercial Fishing Permit and Sportfishing License before operating commercial tackle to take shovelnose sturgeon, and as of 2002 it became illegal for commercial fishermen (or fish farmers) to take, possess, or sell shovelnose sturgeon, or parts thereof (including roe), without a Resident Roe Taker/Seller Permit, a Resident Roe Taker Helper Permit, a Resident Roe Buyer/Exporter Permit, or a Non-Resident Roe Buyer Permit, as appropriate (AGFC 2001a).

Commercial catch of shovelnose sturgeon is restricted to a season from November 1 to April 30. It remains illegal to commercially take or possess sturgeon from the Mississippi River, including the Arkansas River up to Dam #2, and the White River to Montgomery Point Lock and Dam, as well as in other specified waters closed to commercial fishing (AGFC 2001a, 2001b; pers. comm., B. Posey, Arkansas Game and Fish Commission, September 2002).

Commercial fishing data on shovelnose sturgeon were not collected from 1982 to 2000 (April Layher, Biologist, Fisheries Division, Arkansas Game and Fish Commission, *in litt.* to Teiko Saito, USFWS/OMA, August 18, 2000). Arkansas began collecting data on roe harvest in 2002; the state reported the harvest of 186.71 pounds (~84.7 kg) of shovelnose sturgeon roe in 2002 (pers. comm., B. Posey, Commercial Fishing and Mussel Biologist, AGFC, August, 2002).

Sport catch of shovelnose sturgeon is allowed between November 1 and April 30, concurrent with the commercial season (pers. comm., B. Posey, Arkansas Game and Fish Commission, September 2002). Information detailing the extent of sport catch is not available.

Illinois

Commercial fishing for shovelnose sturgeon is legal in Illinois. There are no catch quotas. There is, however, a gear restriction that makes it illegal to use trammel nets in the Ohio River with less than four-inch bar mesh netting (Illinois Administrative Code, Section 810.20). The state requires commercial fishermen to report the undressed weight of their catch annually, and in the Ohio River by the 10th of

each month following catch, whether or not they have taken any fish (Illinois Administrative Code, Section 830). Prior to 1990, there was no requirement to report the quantity of eggs taken. Table 4.5.1 shows the commercial shovelnose catch and roe harvest reported for the years 1990 to 2001.

Indiana

Indiana allows both commercial and sport fishing for shovelnose sturgeon. Until recently, the state did not maintain catch records for the commercial fishery, which is concentrated in the Wabash River bordering Illinois. Indiana did provide information on shovelnose sturgeon catch for 1998 and 1999, with the caveat that because shovelnose sturgeon catches are not reported as a separate category in the state's interior waters, the figures should be considered as minimums. The catches reported by the state were 53 pounds (total weight) in 1998, and 1,626 pounds (total weight) in 1999. Preliminary data for 2000 indicated a catch of 469 pounds (total weight) (pers. comm., T. Stefanavage, Indiana Department of Natural Resources, February 2002). Indiana also permits a year-round sport fishery; information was not available on catch (Mosher 1999).

Iowa

Iowa allows both commercial and sport fishing for shovelnose sturgeon. There is no commercial catch quota. Todd (1999) reported that an estimated 8,000 kg (17,600 pounds) of shovelnose sturgeon was caught annually in Iowa into the 1990s. Table 4.5.2 shows Iowa's reported commercial catch of shovelnose sturgeon from 1998–2002 (data for roe harvest are available only for 2002).

Iowa also has a year-round sport fishery for shovelnose sturgeon. There is no daily catch

Table 4.5.1 Commercial Shovelnose Sturgeon Catch/Roe Harvest in Illinois, 1990–2001*

Year	Flesh (pounds)	Eggs (pounds)
1990	8,853	47
1991	14,067	155
1992	10,129	152
1993	19,657	221
1994	29,807	0
1995	22,580	125
1996	17,728	249
1997	27,980	234
1998	33,423	782
1999	47,236	3,529
2000	41,035	4,978
2001	65,462	8,197
Total:	***337,957***	***18,227***

* Source: Mike Conlin, Chief, Division of Fisheries, Illinois Department of Natural Resources, *in litt.* to Teiko Saito, Office of Management Authority, USFWS, August 23, 2000; pers. comm., R. Maher, Illinois Department of Natural Resources, February 2003.

Table 4.5.2 Iowa Commercial Catch of Shovelnose Sturgeon, 1998-2002*

Year	Shovelnose Sturgeon (lbs)	Roe (ibs)
1998	19,919	Data not recorded or required
1999	14,016	Data not recorded or required
2000	28,676	Data not recorded or required
2001	26,168	Data not recorded or required
2002	28,203	235

* Source: Boland 1998, 1999, 2000, 2001, 2002.

limit, possession limit, or minimum length limit for the species. The state does not require fishermen to report sport-caught shovelnose sturgeon, so data are not available on the number taken annually (Mosher 1999; Iowa Fishing Regulations 2002).

Kansas

There is no commercial fishery for shovelnose sturgeon in Kansas. Sport fishing is allowed year-round, but little data are available about catch levels (Mosher 1999).

Kentucky

Commercial catch of shovelnose sturgeon is permitted in Kentucky, and catch records have been required of commercial fishermen since 1999. Sport fishing is also permitted, but fishermen are not required to report their catch (Mosher 1999). Table 4.5.3 shows commercial catch of shovelnose sturgeon in Kentucky waters from 1999 through 2002 (data from 2002 are partial).

Louisiana

Catch or possession of any sturgeon species, or parts of any sturgeon species, have been illegal in Louisiana since 1990 (USFWS/GSMFC 1995).

Minnesota

There is no commercial catch of shovelnose sturgeon in Minnesota (Todd 1999). Sport fishing is permitted only in the state's boundary waters with Wisconsin, downstream from Red Wing Dam. There is no closed season or minimum size restriction; there is a 10-fish per day possession limit, and high-grading is illegal. Minnesota allows no sturgeon fishing in inland waters of the state, or in boundary waters with North Dakota or South Dakota (Minnesota Department of Natural Resources [DNR] 2002a).

Mississippi

All Mississippi waters have been closed to the commercial catch of all sturgeon species since 1974. Mississippi waters are also closed to sport fishing for shovelnose sturgeon (USFWS/GSMFC 1995; Mosher 1999; MDWFP 2000b).

Missouri

Missouri allows commercial fishing of shovelnose sturgeon, and reported a ten-year average annual catch of 7,925 kg (17,435 pounds) as of 1998. A 52-year mean annual commercial catch of shovelnose sturgeon in Missouri was reported to have been 10,000 kg (22,000 pounds) (Todd 1999). More recent data indicate that the catch increased significantly in 2001. Table 4.5.4 shows Missouri shovelnose sturgeon catches from 1999 to 2001 in the Missouri and Mississippi rivers. The state has not monitored the harvest of roe, so data are available only on the total pounds caught.

Requirements for commercial permits, fees for use of nets and other gear, gear restrictions, waters closed to snagging or commercial fishing, and reporting requirements are the same as those for paddlefish (see section 4.4). In addition, in the Missouri River, the part of

Table 4.5.3 Commercial Catch of Shovelnose Sturgeon in Kentucky Waters, 1999–2002 (partial)*

	1999+		2000		2001		2002++	
Water Body	**Flesh (lbs)**	**Eggs (lbs)**	**Flesh (lbs)**	**Eggs (lbs)**	**Flesh (lbs)**	**Eggs (lbs)**	**Flesh (lbs)**	**Eggs (lbs)**
Barkley Lake	2	—	1,300	—	—	—	—	—
Kentucky Lake	—	—	—	—	100	—	—	—
Mississippi River	25	—	9,938	527	13,059	1,021	8,324	731
Ohio River	1,070	101	2,349	287	5,308	500	5,511	269
Tennessee River	—	—	25	—	30	—	—	—
Total:	1,097	101	13,612	814	18,497	1,521	13,835	1,000

* Source: Kentucky Department of Fish and Wildlife Resources.

\+ Harvest totals for each license year March 1 through February 28.

++ Harvest totals for March 1, 2002 through November 30, 2002.

Table 4.5.4 Missouri Commercial Shovelnose Sturgeon Catch (lbs), 1999–2001*

Year	Mississippi River	Missouri River
1999	12,183	7,472
2000	17,544	5,850
2001	65,128	12,370

* Source: pers. comm., V. Travnichek, Missouri Department of Conservation, February 2003.

the St. Francis River that forms the border between Missouri and Arkansas, and most of the state's portion of the Mississippi River, shovelnose sturgeon longer than 30 inches (measured from tip of snout to fork of tail) may not be possessed or transported during commercial fishing operations. Such fish must be returned to the water unharmed immediately after being caught (Wildlife Code of Missouri, 3CSR10-10.725). The state permits year-round sport fishing for the species (Mosher 1999).

Montana

Montana does not permit commercial fishing of shovelnose sturgeon. It does permit sport fishing, with a daily creel limit of five per day (Mosher 1999).

Nebraska

The shovelnose sturgeon is classified as a sport fish in Nebraska. There is no commercial catch allowed. Sport fishing is permitted in inland waters and waters of the Missouri River downstream from the mouth of the Big Sioux River only. The state has established a daily bag limit of 10 fish, and a possession limit of 20 fish (Nebraska Fisheries regulations, Chapter 2.006 "Sport Fishing Regulations").

North Dakota

There is no commercial or sport fishery for shovelnose sturgeon in North Dakota (Todd 1999; Mosher 1999).

Ohio

The shovelnose sturgeon is listed as an endangered species in the state of Ohio. Therefore, no take or trade is permitted (Ohio Code, Section 1501:31-23-01 "Special Endangered Wild Animal Regulations"). As is discussed in more detail in Section VI on Hatcheries and Commercial Aquaculture, one component of the state's management plan for the species has involved captive propagation of shovelnose sturgeon for reintroduction purposes.

Oklahoma

The shovelnose sturgeon is classified as a sport fish in Oklahoma. There is no daily creel limit or minimum size limit on catch (Oklahoma 2002 Fishing Guide).

South Dakota

The state prohibits any catch of all sturgeon species by commercial or sport methods (Todd 1999; Mosher 1999).

Tennessee

Tennessee allows both commercial and sport fishing for shovelnose sturgeon. Like many other states, prior to 1998 the state did not keep commercial catch records or impose any special regulations. In 1998, Tennessee adopted new regulations covering both paddlefish and shovelnose sturgeon. Prior to 2002, commercial catch regulations for shovelnose sturgeon were the same as those that covered paddlefish, with the exception that there were no size limits for shovelnose sturgeon. In November of 2002 the Tennessee Wildlife Resources Commission prohibited the possession of shovelnose sturgeon greater than 30 inches in length (TWRA 2003). Many of the reporting requirements and restrictions on the sale, importation and exportation of shovelnose sturgeon (including roe) are the same as those for paddlefish (see section 4.4).

Catch for 1998, the first year of reporting, was reported by fishermen to be 236 pounds of fish and 4 pounds of eggs. In 1999, the reported catch grew to 1,040 pounds of fish and 385 pounds of eggs (TWRA 2001). There was no reported commercial catch of shovelnose sturgeon from Tennessee waters during 2000. In 2001, the preliminary estimated commercial catch of shovelnose sturgeon was 3,023 pounds

of fish and 926 pounds of eggs (pers. comm., R. Todd, TWRA, February 2003). Tennessee also allows sport catch of the species (Mosher 1999).

Texas

The shovelnose sturgeon is listed as a threatened species in Texas. No commercial or sport catch is permitted (Todd 1999; Mosher 1999; TDPW 2002a).

West Virginia

The shovelnose sturgeon is a protected species in West Virginia; there is no commercial or sport fishing (pers. comm., C. O'Bara, West Virginia Division of Natural Resources, January 2003). As is discussed in more detail in Section VI on Hatcheries and Commercial Aquaculture, one component of the state's management plan for the species involves stocking shovelnose sturgeon.

Wisconsin

Wisconsin allows commercial catch of shovelnose sturgeon, and as of 1998 reported an average annual catch of approximately 850 kilograms (1,870 pounds) (Todd 1999). The state also permits a year-round sport fishery (Mosher 1999).

Wyoming

The shovelnose sturgeon is classified as a game fish in Wyoming. The state permits sport fishing for the species year-round, except as prescribed for specifically designated waters or drainages. There is a daily creel limit of two fish; snagging is illegal. It is also illegal to sell, barter, dispose of, abandon, or obtain by sale or barter any edible portion of any game fish in Wyoming (2002 through 2003 Wyoming Fishing Regulations). As is discussed in more detail in Section VI on Hatcheries and Commercial Aquaculture, Wyoming's management plan for the species has included stocking of shovelnose sturgeon.

4.6 Pallid Sturgeon

The pallid sturgeon is listed as an endangered species under the ESA, and is also designated as endangered in all U.S. states throughout its range. There is no commercial or sport catch permitted in any state. As is discussed in Section VI under Hatcheries and Commercial Aquaculture, current management strategies for the species at both the federal and state levels are largely focused on captive propagation efforts until habitat restoration and recovery efforts show some success in restoring natural reproduction.

The National Audubon Society first petitioned USFWS to list the pallid sturgeon as an endangered species in 1978. That petition was denied for lack of sufficient evidence of threats. In 1982, USFWS included the pallid sturgeon in a notice of review for species under consideration for listing as endangered or threatened. In 1988, the Dakota Chapter of the Sierra Club petitioned the USFWS to list the pallid sturgeon as an endangered species; a positive finding was made in that year, and published in 1989. In October, 1990, a Final Rule was published listing the pallid sturgeon as an endangered species under the ESA (USFWS 1990). USFWS published a recovery plan for the pallid sturgeon in 1993 (USFWS 1993).

Conservation and management plans for the pallid sturgeon, as well as for the endangered piping plover and least tern, are the subject of political battles regarding navigation projects and seasonal water flow issues affecting critical habitat in the upper reaches of the Mississippi and Missouri rivers. Section 7 of the ESA requires all federal agencies to assist in the conservation of listed species, and to consult with USFWS when activities they fund, permit, or undertake may have adverse effects on threatened or endangered plants or animals (USFWS 2001e). Section 7 consultations were necessary for the pallid sturgeon and other endangered species dependent upon the Upper Mississippi and Missouri rivers because of ongoing and planned navigation projects and activities proposed by the U.S. Army Corps of Engineers (USFWS 2000e–g). The biological opinions and Reasonable and Prudent Alternatives (RPA) issued by USFWS are illustrative of the process, and highlight current challenges facing management and recovery of the pallid sturgeon.

In May 2000, USFWS released a Biological Opinion on the continued operation and maintenance of the Upper Mississippi River navigation channel and associated locks and dams over the next 50 years. Working with the Army Corps of Engineers, USFWS studied the

river from Minneapolis, Minnesota, to Cairo, Illinois. USFWS examined potential impacts on indigenous threatened and endangered species from the lock and dam system operation; channel maintenance, dredging, and material disposal; construction and maintenance of channel training structures; and other activities, including navigation. The Biological Opinion found that these activities jeopardized the pallid sturgeon because habitat degradation would continue (MICRA 2000; USFWS 2000e, 2000f).

The Upper Mississippi RPA issued by USFWS included implementation of a long-term habitat restoration program and a pallid sturgeon habitat/life history study in the Mississippi River as a way to protect endangered and threatened species in the area while allowing other activities such as commercial navigation to take place (MICRA 2000; USFWS 2000e, 2000f).

The Army Corps of Engineers completed planning for the Pallid Sturgeon Habitat and Population Demographics Study, and the study was initiated in Summer of 2002. As of the end of 2002, information had been collected for 14 pallid sturgeon. A habitat map (based on bottom bathymetry), a stone-dike inventory of the Middle Mississippi River (lower 200 miles of the Upper Mississippi River), and a side-channel restoration plan have been completed. In addition, as of the beginning of 2003 the Corps was in the process of completing a historical, comparative geomorphological map of the Middle Mississippi River. This information, as well as information from the habitat and demographics study, will be integrated into a Pallid Sturgeon Restoration and Conservation Plan that will guide future habitat restoration as the Corps moves into implementing a long-term habitat restoration program. In the interim, the Corps is completing short term habitat restoration projects (e.g., pilot projects) for the benefit of pallid sturgeon (pers. comm., J. Collins, USFWS, January 2003).

In 2001 and 2002, the Corps also completed an effort for adding woody debris piles and structures to the river. It is almost certain that these structures will attract numerous invertebrates and fish, but they are also anticipated to provide flow and depth diversity. In 2003, the Corps plans to construct a chevron dike with an associated sand island and complete habitat improvements in one of the few remaining side channels (pers. comm., J. Collins, USFWS, January 2003).

In November 2000, USFWS and the Army Corps of Engineers released another Biological Opinion regarding the potential for conservation of endangered species in the Missouri River, while continuing operation of Missouri River dams and reservoirs and conducting a bank stabilization and navigation project and other related operations in the Kansas River tributary reservoirs. USFWS concluded that continuation of present operations was likely to jeopardize the pallid sturgeon and other endangered species in the ecosystem, and detailed conservation actions necessary to return the Missouri River to a more natural river system in an RPA (USFWS 2000b, 2000g).

The Missouri RPA contained five parts, which in concert were designed to eliminate jeopardy to the pallid sturgeon and other species. The parts included: (1) Flow enhancement by implementing a spring rise every third year and a summer draw-down from Gavins Point Dam in order to restore spawning cues for fish; maintaining and developing sandbar habitat, enhancing aquatic habitat by connecting the main channel to backwaters and side channels; and a spring release from Fort Peck Dam to provide spawning cues and increase the amount of warm water habitat for pallid sturgeon and other native fish; (2) Restoration, enhancement, and conservation of a portion of historic habitat in riverine sections that benefit the pallid sturgeon and other species, with a goal of 20–30 acres of shallow waters per mile; (3) Unbalanced system regulation of three upper reservoirs, when runoff conditions permit, by holding one reservoir at low levels, one at average levels, and one rising on a three-year rotation (primarily for listed terns and plovers); (4) implementation of an adaptive management process that allows efficient modification/implementation of actions in response to new information or changing environmental conditions; and (5) an increase in pallid sturgeon propagation and augmentation efforts while habitat and hydrology improvements are being implemented (USFWS 2000b, 2000g).

In October 2001, the Army Corps of Engineers sent a letter to USFWS documenting their plan to respond to the Missouri River Biological Opinion. In November 2001 the Corps and USFWS met and agreed that the Corps was making sufficient progress in meeting the milestones identified in the biological opinion to implement elements of the RPA. In January 2002, the National Academy of Sciences' National Research Council issued a report on the status of the Missouri River ecosystem which affirmed the direction of the biological opinion (Collins 2002).

As of the end of 2002, USFWS was back in formal consultation with the Corps on issues related to the future operation of the river (pers. comm., M. Olson, USFWS, January 2003). There is some concern that this re-initiation of formal consultation between USFWS and the Corps may indicate a reluctance on the part of the Corps to follow through with implementation of the RPA.

The ultimate success of management and recovery efforts for pallid sturgeon in both the Mississippi and Missouri rivers are not likely to become apparent for some time. In addition, it should be noted that the course and implementation of ongoing and planned recovery efforts, RPAs, and Army Corps of Engineers projects are contingent upon the provision of funding through congressional appropriations, as well as on political will at the state and federal levels.

4.7 Alabama Sturgeon

Because it is a federally endangered species listed under the ESA in 2000, both state and federal authorities have management responsibilities for the Alabama sturgeon. Both of the species' U.S. historic range states, Alabama and Mississippi, have closed their waters to any commercial or sport catch of sturgeon species (USFWS/GSMFC 1995). In addition, Alabama classifies the Alabama sturgeon—which it officially designates as the "Alabama shovelnose sturgeon"—as a protected nongame species. Under Alabama Nongame Species Regulation 220-2.92, it is illegal to "take, capture, kill, or attempt to take, capture or kill, possess, sell, trade for anything of monetary value, or offer to sell or trade for anything of monetary value" such species without a scientific collection permit or written permit from the Commissioner of the Alabama Department of Conservation and Natural Resources [ADCNR]. Mississippi classifies the "Alabama shovelnose sturgeon" as a state endangered species; however, the Alabama sturgeon is believed to be currently extant only in portions of the lower Alabama River in three counties in Alabama (Anon. 2000b, MDWFP 2000b).

At the federal level, the Alabama sturgeon was included in Federal Register notices of review for ESA candidate species in 1982, 1985, 1989, and 1991. The 1982 and 1985 notices listed the Alabama sturgeon as a category 2 candidate species, while the 1989 and 1991 notices listed it as a category 1 species. In 1993, USFWS published a proposed rule to list the Alabama sturgeon as endangered, with a proposed designation of critical habitat. After one extension of the deadline, in December 1994 USFWS withdrew the proposed rule on the basis of insufficient evidence that the Alabama sturgeon continued to exist. In September 1997, after the capture of four sturgeon confirmed the species' continued existence, USFWS reclassified the Alabama sturgeon as a candidate species. In March 1999, USFWS published another proposed rule to list the species as endangered; the listing did not include the proposed designation of critical habitat. The Final Rule designating the species as endangered under the ESA was published in the Federal Register on May 5, 2000 (Anon. 2000b; USFWS 2000c).

Prior to the final ESA listing, in early 1997 a collaborative, public/private effort was initiated to conserve the Alabama sturgeon. Because the primary threats facing the species were believed to be its small numbers and inability to offset mortality rates through natural reproduction, the immediate focus of the effort was to prevent the Alabama sturgeon's extinction through a captive breeding program and release of propagated fish. Other objectives of the plan included habitat restoration and research to determine life history information on the species to facilitate effective conservation and management of remaining Alabama sturgeon populations. The ADCNR implemented this voluntary conservation plan with the participation and/or endorsement of other agencies and groups, including USFWS, the Army Corps of Engineers, the Alabama-

Tombigbee Rivers Coalition, the Geological Survey of Alabama, and the Mobile River Basin Coalition (Anon. 2000b).

In February 2000, USFWS, ADCNR, the U.S. Army Corps of Engineers, and the Alabama-Tombigbee Rivers Coalition signed "A Conservation Agreement for the Alabama Sturgeon (*Scaphirynchus suttkusi*)" and "A Conservation Strategy for the Alabama Sturgeon (*Scaphirynchus suttkusi*)." The Agreement and Strategy were developed to expedite conservation measures designed to ensure the continued existence and recovery of the Alabama sturgeon, consistent with its listing under the ESA, and to continue and expand the activities outlined in the 1997 voluntary conservation plan (Anon. 2000b).

The broad goal of the agreement is to eliminate or significantly reduce current threats to the Alabama sturgeon. Specific conservation and management steps envisioned under the Agreement and Strategy included the following: (1) capture and maintain Alabama sturgeon broodstock for hatchery propagation; (2) develop and maintain hatchery and holding facilities and techniques for the species; (3) implement an intensive culture program; (4) protect existing occupied habitat; (5) conduct habitat studies; (6) conduct studies and develop information on life history and habitat parameters, and apply this information to occupied habitat and population management strategies; (7) apply research results to improve occupied habitat conditions; (8) augment the Alabama sturgeon population in the lower Alabama River; (9) reintroduce the species into suitable portions of its current occupied habitat, where appropriate; (10) establish a process for information transfer between the involved parties and the interested public; and (11) use genetic techniques in the management of the propagation process to ensure genetic diversity (Anon. 2000b; USFWS 2000c).

Several of these conservation and management activities are in the process of being implemented. For example, efforts to collect broodstock have been underway since 1997, coordinated by ADCNR. Hatchery facilities have been constructed, and equipment purchased to hold and propagate Alabama sturgeon at the ADCNR Marion State Fish Hatchery. Numerous federal and state actions and regulatory activities have been reviewed for effects on the Alabama sturgeon. Prey density studies and larval and young-of-year fish surveys have been conducted in the lower Alabama River (Anon. 2000b).

The term of the 2000 Agreement was 10 years, with funding for implementation of both the Agreement and the Strategy envisioned as being provided by a mixture of federal, state, and private sources (Anon. 2000b). As with other endangered species, the future implementation of management and conservation activities set forth in the Agreement and Strategy are dependent upon appropriations and, where applicable, the availability of nongovernmental funding.

4.8 Lake Sturgeon

Lake sturgeon populations exist in both Canada and the United States; neither country has designated the species as federally threatened or endangered. The management structure for the species is similar to that for the paddlefish and shovelnose sturgeon. A key difference, however, is that the species also falls under the jurisdiction of an international body, the Great Lakes Fisheries Commission, in addition to state and provincial management authorities.

The Great Lakes Fisheries Commission (GLFC) was established in 1955 by the Convention on Great Lakes Fisheries between the United States and Canada. Its primary responsibility is to develop coordinated research programs in the Great Lakes and recommend measures that permit the maximum sustained productivity of stocks of fish species of common concern. It is also charged with formulating and implementing a program to eradicate or minimize non-native sea lamprey populations in the Great Lakes. The Commission supports the work of several committees and boards that focus on the management of various fisheries, and are composed of state, provincial, tribal, and federal officials whose duties involve multi-jurisdictional fishery management. The Commission assists in the coordination of management and law enforcement efforts between jurisdictions in the United States and Canada regarding the lake sturgeon (GLFC

2000). Beyond that level of international coordination, summaries of the lake sturgeon management regimes in Canada and the United States are provided below.

Canada

Canadian lake sturgeon populations are protected and managed under the Federal Fisheries Act in each province in which they occur. The following describes the management and catch regulations set by provincial authorities.

Alberta

Alberta contains only two lake sturgeon populations. One population, which is located in the South Saskatchewan River system, is believed to be relatively stable, although it is estimated at fewer than 5,000 fish. The other population resides in the North Saskatchewan River system. This population is considered vulnerable, with possibly fewer than 1,000 fish (Alberta Government 1997–2001).

Significant catch pressure by gill net and long line prior to 1940 is believed to have caused the near extirpation of lake sturgeon populations in Alberta. The province closed all commercial and sport fishing for the species between 1940 and 1968, which allowed populations to recover enough to reopen a closely regulated sport fishery. However, the cumulative catch from the reopened sport fishery is believed to have influenced the number of lake sturgeon that survive to older ages. The majority of sturgeon caught are immature fish under the age of 12, measuring less than 40 inches (100 cm) and weighing less than 20 pounds (9 kg). Sturgeon over 60 pounds (27 kg) are reported only occasionally (Alberta Government 1997–2001).

Alberta approved a Lake Sturgeon Management Plan in November 1996; the plan entered into full effect on April 1, 1997. Prior to implementation of the plan, regulations in the sport fishery allowed catch of two sturgeon per year greater than 40 inches (100 cm) in length. While it was believed that such a limitation was succeeding in maintaining the lake sturgeon populations, it was no longer promoting species recovery because of increased fishing pressure (Alberta Government 1997–2001).

In 1996, Alberta surveyed sturgeon anglers for their input into management of the species. Based largely on that input, a key management objective became "to manage sturgeon populations to continue their recovery and produce more fish, as well as larger sizes and older ages of fish." Differences in fish-use patterns between the North Saskatchewan River system and the South Saskatchewan River system, coupled with the different abundance levels of lake sturgeon in the two river systems, indicated that the two systems should be managed separately (Alberta Government 1997–2001).

Under sport fishing regulations in place since 1997, there is a zero catch limit in the North Saskatchewan River; the fishery is catch-and-release only. Catch is still allowed in the South Saskatchewan River and its tributaries, including the Oldman, Bow, and Red Deer rivers. A Sturgeon fishing license is required, which is valid for the take of one sturgeon per year. There is no separate Indian fishery in the province. People registered as Indians under the Indian Act must obtain a sturgeon fishing license to keep a lake sturgeon. A minimum size limit of 52 inches (130 cm) is now in place, reflecting angler preference for large rather than small sturgeon, and an estimate that female lake sturgeon reach sexual maturity at 52 to 56 inches (130–140 cm) in length. Lake sturgeon can be retained only between June 16 and March 31; catch-and-release fishing is permitted between April 1 and June 15, but retention is prohibited to protect spawning runs. Bowfishing and spearfishing for lake sturgeon is prohibited. Each sturgeon kept must be tagged immediately (the tag is provided with the sturgeon fishing license) and the tag may not be removed until the fish is prepared for taxidermy or consumption (Alberta Government 1997–2001, 2001).

Manitoba

The few remaining commercial lake sturgeon fisheries in Manitoba closed during the 1990s, when the catch level and value decreased significantly. The province imposed a possession limit of zero in 1995 (CITES Management Authority of Canada, *in litt*. to TRAFFIC Europe, August 2000). Table 4.8.1 shows catch levels and value during the years leading up to the closure.

Table 4.8.1 Production and Value of Lake Sturgeon Fisheries in Manitoba, 1985–1996*

	Commercial Fishing Production	
Year	Production (kg)	Value ($CAD 2001)
1985/86	5,650	N/A
1986/87	4,750	N/A
1987/88	5,300	N/A
1988/89	7,400	N/A
1989/90	7,150	N/A
1990/91	4,100	46,718
1991/92	3,650	30,294
1992/93	1,600	12,070
1993/94	200	3,408
1994/95	500	3,651
1995/96	N/A	3,782
Average:	***4,030***	***$9,992***

Key: N/A = Not available.

* Source: Manitoba Conservation (2001a).

There is no commercial or sport catch of lake sturgeon at present. Catch-and-release fishing is still legal in many rivers, as is aboriginal subsistence fishing (Manitoba Conservation 2001b). Management efforts have begun in several rivers with the cooperation of First Nations tribes (CITES Management Authority of Canada, *in litt*. to TRAFFIC Europe, August 2000).

Ontario

Ontario allows both commercial and sport fishing for lake sturgeon. Table 4.8.2 shows the total reported lake sturgeon commercial catch for Ontario from 1994 to 1999 (Al Murray, MNR Lake Erie Management Unit, *in litt*. to Robert Jones, DFO, August 30, 2000).

Commercial catch quotas were allocated in 1984 based on annual performance by individual fishermen from 1978 to 1982. Lake sturgeon are commercially fished in Lake Huron, Lake Nipigon, Lake St. Clair, Namakan Lake, Rainy Lake, and the Seine River. Lakes Huron and St. Clair are shared by both Canada and the United States. Commercial catch of lake sturgeon, however, is allowed only in Ontario waters. Ontario's catch quota for the years 1998–2000 was 25,417 pounds (11,553 kg) (P. Hall, DFO, *in litt*. to TRAFFIC North America, September 28, 2001). As indicated in Table 4.8.2, catch levels in recent years were well within these quotas.

Since 1995 a Lake Sturgeon Assessment Programme has been implemented, including population abundance estimates and tagging to identify movements and verify ages. All commercial fishermen in Ontario are required to fill out a daily catch report, and the information in these reports is compiled in the Ontario Commercial Fish Catch Information

Table 4.8.2 Ontario Commercial Catch of Lake Sturgeon, 1994–1999*

Year	Total Catch (pounds)	Total Value ($CAD)
1994	18,362	41,681
1995	10,988	26,229
1996	12,668	30,399
1997	13,206	35,906
1998	14,696	38,684
1999	13,746	N/A

Key: N/A = Not available.

* Source: Al Murray, MNR Lake Erie Management Unit, *in litt.* to Robert Jones, DFO, August 30, 2000.

Table 4.8.3 Ontario Commercial Catch of Lake Sturgeon by Fishery, 1998–1999*

Total Catch	1998 (pounds)	1999 (pounds)
Lake Huron	10,644	10,444
Lake Nipigon	52	82
Lake St. Clair	1,746	1,665
Namakan Lake	1,575	1,070
Rainy Lake	391	223
Seine River	40	262

* Source: Al Murray, MNR Lake Erie Management Unit, *in litt.* to Robert Jones, DFO, August 30, 2000.

System (CFHIS). A management plan will be implemented after sufficient data are collected. In the meantime, quotas will not increase, but may decrease based on data analysis. Data from CFHIS showing a breakdown of catch by water body are available for 1998 and 1999, and are shown in Table 4.8.3.

Ontario also allows sport fishing for lake sturgeon. Statistics from a DFO survey of recreational fishing in Canada for the year 2000 recorded the catch of 53,313 sturgeon in Ontario. Because the lake sturgeon is the only sturgeon species extant in the province, these figures are presumably for lake sturgeon. The data indicated that of the sturgeon caught, 5,379 were retained (DFO 2002a, 2002b).

Quebec

Quebec allows sport and commercial fishing for lake sturgeon. The commercial gill net season begins after spawning on June 14, and lasts until October 31. Therefore, there is no harvest of roe. The minimum size limit is 45 cm (18 inches), measured as the distance from the posterior edge of the branchial slit to the posterior joint of the dorsal fin (Environment Canada 2000). Commercial catch must be tagged as soon as fish are caught, and remain tagged until processed for human consumption. The province issues a specified number of tags to each commercial fisherman to enforce catch limits (CITES Management Authority of Canada, *in litt*. to TRAFFIC Europe, August 2000).

As shown in Table 4.8.4, Quebec's commercial lake sturgeon catch averaged approximately 207,000 kg (~455,400 pounds) per year between 1986 and 1994. The highest catch during this period was 246,000 kg (541,200 pounds) in 1987, and the lowest catch was 158,000 kg (347,600 pounds) in 1989.

More recent information indicates that these catch levels have remained fairly steady. In 1997, commercial catch in Quebec's rivers and lakes totaled 208,714 kilograms (459,171 pounds), with approximately 96% of the catch coming from the St. Lawrence River, where there were 77 licensed fishermen (DFO, *in litt*.

Table 4.8.4 Quebec Commercial Catch of Lake Sturgeon, 1986–1994*

Year	Commercial Catch (kg)
1986	184,000
1987	246,000
1988	173,000
1989	158,000
1990	222,000
1991	217,000
1992	223,000
1993	225,000
1994	214,000
Average:	***206,800***

* Source: P. Dumont, *in litt.* to TRAFFIC Europe, 1995.

to the CITES Management Authority of Canada, June 9, 2000). In 1998, Quebec reported a commercial lake sturgeon catch of 458,864 pounds (208,575 kg), and in 1999 the province reported a catch of 394,695 pounds (179,407 kg) (P. Hall, DFO, *in litt*. to TRAFFIC North America, September 28, 2001).

Beginning in 1999, Quebec established catch quotas and a system of Total Allowable Catch (TAC) on the province's lake sturgeon fishery. In 1999, the catch quota was set at 441,000 pounds (200,455 kg), with a TAC of 30,433 fish. In 2000 the catch quota was set at 382,800 pounds (174,000 kg), with a TAC of 24,345 fish (P. Hall, DFO, *in litt*. to TRAFFIC North America, September 28, 2001).

The catch and possession limit in Quebec's sport fishery is one per day. The sport fishery is believed to consist of a few hundred fish per year taken in the Montreal area (CITES Management Authority of Canada, *in litt*. to TRAFFIC Europe, August 2000).

Saskatchewan

Saskatchewan has a commercial lake sturgeon quota of 4,500 kilograms (9,900 pounds) on the lower Saskatchewan River. However, declining catches led to a provincially imposed moratorium that has been in place since 1996 (CITES Management Authority of Canada, *in litt*. to TRAFFIC Europe, August 2000). Although retention of lake sturgeon caught by sport anglers has not been permitted since 1999, DFO data indicated that catch-and-release fishing continued. Catch and retention records from the DFO showed the catch of 4,193 sturgeon in Saskatchewan in the year 2000, with none retained (DFO 2002a, 2002b). Because the lake sturgeon is the only sturgeon species extant in Saskatchewan, these statistics are presumably for lake sturgeon. A multi-agency study of habitat, fish migration, and abundance is underway (CITES Management Authority of Canada, *in litt*. to TRAFFIC Europe, August 2000).

The United States

Regulations regarding commercial and sport catch of lake sturgeon are the responsibility of individual states. The following summaries describe the lake sturgeon management and catch regulations of U.S. states within the species' range.

Alabama

Lake sturgeon are presumed to be extirpated from the state, based on the lack of any recent collections (Stan Cook, Chief of Fisheries, Alabama Department of Conservation and Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 15, 2000).

Arkansas

Lake sturgeon are reported to have once inhabited Arkansas waters. However, the species is believed to have been extirpated long ago (April Layher, Biologist, Fisheries Division, Arkansas Game and Fish Commission, *in litt*. to Teiko Saito, USFWS/OMA, August 18, 2000).

Illinois

The lake sturgeon is classified as an endangered species in Illinois (Illinois Administrative Code, 1010.30). No commercial or recreational catch is permitted (Mosher 1999; Todd 1999; Mike Conlin Chief, Division of Fisheries, Illinois Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 23, 2000).

Indiana

The lake sturgeon is classified as an endangered species in Indiana (Indiana DNR 2001). No commercial or sport catch is permitted (Mosher 1999; Todd 1999).

Iowa

A small population of lake sturgeon is found in the Mississippi River in Iowa waters. The species is on Iowa's endangered species list, and no commercial or sport catch is permitted. Under the Iowa Code, Section 481 B.5, "Prohibitions," a person may not "take, possess, transport, import, export, process, sell or offer for sale, buy or offer to buy, nor shall a common or contract carrier transport or receive for shipment, any species of fish, plants, or wildlife…" that appear on the state's list of species determined to be endangered or threatened within the state, as well as federally threatened or endangered species, whether indigenous to the United States or foreign

(Marion Conover, Chief, Fisheries Bureau, Iowa Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 14, 2000).

Kansas

Lake sturgeon in Kansas are currently limited to the Missouri River and possibly the lower Kansas River. There is no commercial season for the species; however, as of 2000 those who caught lake sturgeon incidentally by legal means in other fisheries were not prohibited from keeping them (T. Mosher, Fisheries Research Coordinator, Kansas Department of Wildlife and Parks, *in litt*. to Teiko Saito, USFWS/OMA, August 17, 2000).

Kentucky

Lake sturgeon are included on the Species in Kentucky List published by the Kentucky Department of Fish and Wildlife Resources (KDFWR 2002), although the species' status in the state is uncertain. Recent reports of lake sturgeon seen in Kentucky waters come mainly from the western portion of the state, in the Ohio and Mississippi rivers, where the fish most likely come from Missouri stockings. However, one fish collected by the KDFWR in state waters had a tag placed on it by biologists working with lake sturgeon populations still existing in the White River Drainage (a tributary of the Wabash River) (pers. comm., D. Henley, KDFWR, January 2003). There is no commercial or sport fishery for lake sturgeon in Kentucky (Mosher 1999; Todd 1999). By law, commercial anglers are required to release any lake sturgeon caught in Kentucky waters. While this law has not been actively enforced in the past, the state is sending flyers with new commercial fishing licenses stating that this regulation will be enforced beginning in March 2003 (pers. comm., D. Henley, KDFWR, January 2003).

Louisiana

There are no contemporary accounts of lake sturgeon in Louisiana. Even if there were, it has been illegal to catch or possess any sturgeon species or its body parts since 1990 (USFWS/GSMFC 1995; John Roussel, Assistant Secretary, Office of Fisheries, Louisiana Department of Wildlife and Fisheries, *in litt*. to Teiko Saito, USFWS/OMA, August 25, 2000).

Michigan

Commercial catch of lake sturgeon in Michigan has been prohibited since the 1950s, and according to state officials will remain closed (Gary Whelan, Fish Production Manager, Michigan Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 29, 2000). The species has been listed as threatened under the Michigan Endangered Species Act since 1994.

In 1997, the state published a Lake Sturgeon Rehabilitation Strategy. Its primary goal was to conserve and rehabilitate self-sustaining populations of lake sturgeon to a level that would permit delisting from its threatened status. There were three sub-goals: (1) where populations now exist, conserve or rehabilitate self-sustaining lake sturgeon populations; (2) where populations have been extirpated, re-establish self-sustaining lake sturgeon populations when possible to their known former range; and (3) where opportunities arise, re-establish self-sustaining lake sturgeon populations in waters with appropriate habitat and within their suspected former range (Hay-Chmielewski and Whelan 1997).

In April 1999, Michigan changed its regulations for sport fishing to significantly reduce mortality of lake sturgeon and allow for an increased rate of population recovery. Prior to 1999 most of the state was open to sport catch with a minimum size limit of 50 inches and an annual catch of one fish per licensed fisherman. Open seasons varied among bodies of water.

More recently, sport fishing has been allowed in only five areas (Menominee River, Black Lake, Otsego Lake, Lake St. Clair, and the St. Clair River). Catch-and-release fishing is allowed in Great Lakes waters and all other inland waters from July 16 to March 31, but retention is prohibited, with a penalty of $1,500 per illegal sturgeon on top of penalties for illegal take of a threatened species (Gary Whelan, Fish Production Manager, Michigan Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 29, 2000; 2002 Michigan Fishing Guide).

On the Menominee River, which borders Wisconsin, there are alternating seasons. In 2000, the fishery was open from September 2

to November 1 for hook-and-line fishing with a 70-inch minimum size restriction and a possession limit of one fish per season. In 2001 the fishery was open for the same season with a minimum size restriction of 50 inches and a possession limit of one fish per season. This regulation strategy is expected to continue to alternate in future years. All anglers must have a free tag to fish and all fish must be registered (Gary Whelan, Fish Production Manager, Michigan Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 29, 2000).

The Black Lake (Cheboygan County) fishery is a spear fishery that has a total quota of five fish per year with a minimum size of 36 inches. This is a strictly regulated fishery with only five tags issued for each fish remaining in the quota and a season lasting only two weeks during the last part of February. Otsego Lake (Otsego County) is open year-round to catch with a 42-inch minimum size restriction and an annual possession limit of one fish per fisherman. A free locking tag is required and all fish must be registered. Lake St. Clair and the St. Clair River (St. Clair and Macomb counties) are open from July 16 to September 30 with a slot length restriction of 42–50 inches and an annual possession limit of one fish. All anglers must obtain a locking tag and register all fish (Gary Whelan, Fish Production Manager, Michigan Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 29, 2000; 2002 Michigan Fishing Guide).

Under this system, the cumulative Michigan sport catch in all fisheries has been between 15 and 105 fish statewide annually, with a total catch weight of between 600 and 4,200 pounds. The annual catch in the Menominee fishery is 55 to 90 fish over the 50-inch minimum size limit and is likely to be 1–3 fish over the 70-inch minimum size limit. The Black Lake catch can be no more than five fish annually under the quota system, the Otsego Lake catch is usually one to five fish annually, and the St. Clair River/Lake St. Clair fishery is approximately five fish annually (Gary Whelan, Fish Production Manager, Michigan Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 29, 2000).

Michigan's lake sturgeon management strategy also involves captive propagation and stocking in selected waters. These activities are discussed in Section VI under Hatcheries and Commercial Aquaculture.

Minnesota

Minnesota does not permit commercial catch of lake sturgeon. The state allows, but closely regulates, a sport fishery for the species in Minnesota-Canada border waters and some waters on the Minnesota-Wisconsin border. No sport catch is permitted on inland waters, in Minnesota-North Dakota or Minnesota-South Dakota border waters, or in the St. Louis River.

In recent years, Minnesota's management strategy for the species has included a target catch of 7,600 pounds per year in Minnesota-Canada border waters, with the catch set at 75% of potential yield to allow recovery (L. Erickson-Eastwood, Fisheries Program Manager, Minnesota Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 23, 2000). A summary of catch for lake sturgeon in the state from 1996 to 2000 is summarized in Table 4.8.5.

Restrictions for the Minnesota-Canada border fishery began to tighten in 2001 in response to increasingly heavy fishing pressure. For example, in 2000 the fishing season was closed from May 15–June 30 to protect spawning runs, and there was a minimum legal size limit of 45

Table 4.8.5 Minnesota Sport Catch of Lake Sturgeon, 1996–2000*

Year	Catch (lbs)
1996	222
1997	1,395
1998	8,636
1999	5,124
2000	9,309

* Source: L. Erickson-Eastwood, Fisheries Program Manager, Minnesota Department of Natural Resources, *in litt.* to Teiko Saito, USFWS/OMA, August 23, 2000.

inches (L. Erickson-Eastwood, Fisheries Program Manager, Minnesota Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 23, 2000). By contrast, in 2002 the fishing season was closed from May 1–June 30, and rather than only a minimum size limit, there was a legal size slot limit of 45–55 inches (Minnesota DNR 2002a). Fishermen are allowed to keep one fish per license year. In late 2002, Minnesota DNR announced a proposal to further restrict catch of lake sturgeon in Canadian border waters by issuing harvest tags to state residents. Under the proposal, Minnesota DNR would issue 300 harvest tags to state residents through a lottery that would allow the catch and possession of one lake sturgeon per tag. Anglers without a tag would still be able to practice catch-and release fishing (Minnesota DNR 2002b). The outcome of that proposal had not yet been determined at the time of the writing of this report.

In Minnesota-Wisconsin border waters, lake sturgeon may be fished from September 7 through October 15 on the St. Croix River, from Taylor Falls Dam downstream to the mouth at Prescott, Wisconsin. The possession limit is one sturgeon per licensed fisherman per season, and the minimum size allowed is 50 inches (Minnesota DNR 2002a).

Minnesota's lake sturgeon management strategy also involves stocking. These activities are discussed in Section VI under Hatcheries and Commercial Aquaculture.

Missouri

The lake sturgeon is classified as an endangered species in Missouri; the state allows no commercial or sport catch (Mosher 1999; Todd 1999; Missouri Department of Conservation 2002). The state has actively promoted and supported efforts to re-establish the species through stocking in the Missouri and Mississippi rivers. These activities are discussed in Section VI under Hatcheries and Commercial Aquaculture.

Nebraska

The lake sturgeon is classified as a threatened species in Nebraska, where the species may be found in inland waters and waters of the Missouri River. There is no commercial or sport catch allowed (Nebraska Administrative Code, Title 163, Chapter 4.004).

New York

The lake sturgeon is classified as a threatened species in New York (New York State Department of Environmental Conservation [NYS/DEC] 1999). All catch or possession is illegal except under license or permit from the New York State Department of Environmental Conservation (Section 11-0535 Environmental Conservation Law of the State of New York; Part 182 Title 6, Codes, Rules and Regulations of the State of New York [NYCRR]). Licenses are available for the importation of lake sturgeon carcasses and the processing of imported lake sturgeon (6NYCRR Section 182.7).

The Department has conducted a lake sturgeon recovery program since 1994. The program has included rearing and stocking lake sturgeon fingerlings in selected target restoration waters since 1995 (NYS/DEC 1999; Patrick Festa, Inland Fisheries Management Section, Department of Environmental Conservation, *in litt*. to Teiko Saito USFWS/OMA, August 22, 2000). This program is described in greater detail in Section VI under Hatcheries and Commercial Aquaculture.

Ohio

The lake sturgeon has been listed as an endangered species in the state of Ohio since 1974 (Gary Isbell, Executive Administrator, Fish Management and Research, Ohio Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 15, 2000). No take or trade is permitted as per Ohio Code, Section 1501:31-23-01, "Special Endangered Wild Animal Regulations." It is illegal to possess lake sturgeon taken from Ohio waters in Lake Erie (Kevin Ramsey, Lake Erie Law Enforcement Supervisor, Ohio Department of Natural Resources Divison of Wildlife, *in litt*. to Andrea Gaski, USFWS/OMA, September 11, 2000).

Pennsylvania

The lake sturgeon is classified as an endangered species in Pennsylvania (PDCNR 2002). Catching, killing, possessing, importing to or exporting from, selling, offering for sale or purchasing of the species or its parts is illegal in the state without a special permit. Lake sturgeon are most likely to be found in Pennsylvania waters in Lake Erie, where small specimens occasionally show up

in the trapnets of the few commercial fishermen permitted to fish those waters. By regulation the fish must be released immediately (Richard Snyder, Chief, Division of Fisheries Management, Pennsylvania Fish and Boat Commission, *in litt*. to Teiko Saito, USFWS/OMA, August 15, 2000).

South Dakota

South Dakota considers the lake sturgeon to occur only occasionally in the state. The lake sturgeon is not legally classified as threatened or endangered by South Dakota, but it is included on a list of rare, threatened, or endangered animals (South Dakota Department of Game, Fish and Parks 2002). There is no catch; South Dakota prohibits any catch of all sturgeon species by either sport or commercial methods (Clifton Stone, Senior Wildlife Biologist, Reservoir Fisheries, South Dakota Department of Game, Fish and Parks, *in litt*. to Rosemarie Gnam, USFWS/OMA, August 25, 2000).

Tennessee

The lake sturgeon is classified as an endangered species in Tennessee. It is illegal to catch them commercially or for sport. Populations of lake sturgeon in the state are believed to be very small, and probably exist only because of restoration efforts through stocking by the Tennessee Valley Authority (TVA) and a recent cooperative effort between the Tennessee Wildlife Resources Agency (TWRA), TVA, USFWS, the University of Tennessee, the Tennessee Aquarium, the Southeast Aquatic Research Institute, World Wildlife Fund, and Conservation Fisheries, Inc. (Robert Todd, Commercial Fishing Coordinator, Tennessee Wildlife Resources Agency, *in litt*. to Teiko Saito, USFWS/OMA, August 21, 2001). In this effort, lake sturgeon are being stocked in the French Broad River above Knoxville, from whence they might migrate to other waters (pers. comm., George Benz, SARI, 2001). This program is discussed in greater detail in Section VI.

Vermont

In Vermont, lake sturgeon are found only in Lake Champlain. The fishery for lake sturgeon was closed in 1967, and the Vermont Agency of Natural Resources (VANR) placed the species on the state endangered species list in 1987. It is illegal to take or possess lake sturgeon without an endangered species permit issued by the Secretary of VANR (Chet MacKenzie, VANR, *in litt*. to Teiko Saito, USFWS/OMA, August 30, 2000).

Wisconsin

Wisconsin allows only sport fishing for lake sturgeon. The state has established two different seasons, a spear fishery in Lake Winnebago that begins in February and a hook and line season from the first Saturday in September through October 15. The Lake Winnebago spear fishery is managed under a quota system, and the season is closed immediately at the end of the next day after 80% of the quota is reached. Quota numbers as of 2000 were 400 adult females, 400 juvenile females, and 2,150 males. Under the quota system in place, once 320 adult females are caught, the season closes at 6:00 p.m. on the following day. There is also a 36-inch minimum length restriction, and fishermen must purchase a $10 sturgeon spearing tag. In the hook and line fishery there is a 50- to 70-inch minimum length restriction depending on location, and anglers must apply for a free tag (Karl Scheidegger, Wisconsin Department of Natural Resources, *in litt*. to Rosemarie Gnam, USFWS/OMA, August 17, 2000). Table 4.8.6 shows the catch totals for the spring spear season and hook and line season from 1998 through 2000.

Wisconsin's lake sturgeon management strategy also involves stocking. These activities are discussed in Section VI under Hatcheries and Commercial Aquaculture.

Table 4.8.6 Wisconsin Sport Catch of Lake Sturgeon, 1998–2000*

Year	Spear Season	Hook and Line Season
1998	2,051	314
1999	1,484	347
2000	2,517	N/A

Key: N/A = Not available.

* Source: Karl Scheidegger, Wisconsin Department of Natural Resources, *in litt* to Rosemarie Gnam, USFWS/OMA, August 17, 2000.

4.9 White Sturgeon

The white sturgeon receives no federal protection in the United States, with the exception of the Kootenai River population that was listed as endangered in the United States on September 6, 1994 (USFWS 1994b). As noted in Section 3.9, the Canadian government listed the white sturgeon as Vulnerable in 1990, based on its limited distribution in Canada; Environment Canada currently places the species in the risk category of Special Concern (Lane 1991; Environment Canada 1999). Management strategies and conservation measures vary at the provincial and state levels in Canada and the United States.

Canada

White sturgeon are extant only in Canadian Pacific coastal waters and in British Columbia's Fraser River system. The species is primarily managed by the British Columbia Ministry of Environment, Lands and Parks (BCMELP). The Canadian DFO shares responsibilities for the species in its coastal and marine habitats (B.C. Fisheries 2001a; Environment Canada 1999). Prior to the 1990 Vulnerable listing by COSEWIC, DFO classified the white sturgeon as both a commercial and a sport fish. Provincial management of the species has changed considerably over the last two decades.

British Columbia

The white sturgeon was fished for sport in British Columbia in the 1980s and into the beginning of the 1990s, long after the historic commercial fishery for the species had collapsed. In 1985, more than 1,000 special permits were issued for the lower Fraser River Valley, and requests for sturgeon sportfishing guiding licenses were reported to be increasing in the province (Environment Canada 1999).

During this period, regulations varied by region within the province. Sport fishermen were allowed to catch one sturgeon per day (either white or green sturgeon) in the Lower Mainland region of the Fraser River, and one sturgeon per year in the Thompson-Nicola, Kootenay, Caribou, Skeena, and Omenica-Peace regions. The minimum size restrictions in all of these regions was 40 inches (100 cm); there was an 80-inch (200 cm) maximum size limit in the Lower Mainland Fraser and Omenica-Peace regions. DFO sport fishing regulations in marine and coastal waters allowed one sturgeon per day, with minimum size set at 40 inches (100 cm). White and green sturgeon were not separated. It became illegal to sell sport-caught sturgeon in 1975 (Lane 1991).

Commercial catches during this period were limited to freshwater; commercial fishermen holding certain classes of licenses could take the species. There were no specific regulations regarding incidental take of sturgeon in the Fraser River gill net salmon fishery (Lane 1991).

Subsequent to its classification as Vulnerable by COSEWIC, however, the B.C. Conservation Data Centre listed the white sturgeon as Imperiled, placing it on the province's Red List. Three populations (Nechako, upper Columbia, and Kootenay), are now classified under the province's highest possible threat ranking of Critically Imperiled (B.C. Fisheries 2001a).

In 1994, British Columbia closed the Fraser River fishery and banned the possession or retention of white sturgeon (RL&L Environmental Services 2000a). The only remaining "catch" of white sturgeon in British Columbia has been in catch-and-release fisheries. Data from the DFO document the capture and release of 1,430 white sturgeon in 1998 and 255 white sturgeon in 1999 in the Harrison, Chehalis, Nicomen-Norrish, Stave and Vedder-Chilliwack sport fisheries. A significant majority of these fish were taken and released in the Harrison River (DFO 2001).

While such catch-and-release fisheries are still allowed in some segments and tributaries of the Fraser River, the practice is increasingly restricted. As of September 7, 2000, angling for sturgeon is no longer permitted in the Nechako River or its tributaries, including the Stuart River. Similar action was previously taken on behalf of the Kootenay/upper Columbia River populations (RL&L Environmental Services 2001a).

White sturgeon management in British Columbia currently focuses on the development of recovery plans to stabilize the remaining population(s) and prevent further declines or even extinction among some distinct population segments. The long-term goal is to restore

abundant, self-sustaining populations to each watershed. To date, recovery plans have focused on: (1) research to identify and address the reasons for the decline of British Columbia white sturgeon populations so that these factors can be mitigated and populations restored to a self-sustaining state (RL&L Environmental Services 2000a, 2000b, 2001a, 2001b); and (2) an interim goal to preserve the remaining gene pool through conservation fish culture, to prevent further loss to the population (B.C. Fisheries 2001a). British Columbia's hatchery program is discussed in greater detail in Section VI on Hatcheries and Commercial Aquaculture.

United States

Similar to the ASMFC on the U.S. eastern seaboard, there is a Pacific Coast Marine Fisheries Commission (PSMFC), which was established as an interstate compact agency in 1947. The goal of PSMFC is "to promote and support policies and actions directed at the conservation, development, and management of fishery resources of mutual concern to member states through a coordinated regional approach to research, monitoring and utilization." Member states are California, Oregon, Washington, and Alaska (PSMFC 2000). Unlike the situation with ASMFC and Atlantic sturgeon, however, PSMFC does not have regulatory authority over Pacific coast sturgeon. U.S. populations of white sturgeon are managed by the range states in which they reside, and in the case of the Columbia River, through a congressionally established compact and interstate agreements. The following summaries describe U.S. state management programs for white sturgeon, with a focus on commercial and sport catch regulations.

Alaska

Alaska classifies the white sturgeon as a commercial fish for purposes of taxation, and provides a species code for tax returns on landings (Alaska Department of Revenue 2001). However, there is not believed to be significant directed commercial or sport fishing for the white sturgeon in the state.

Oregon/Washington

White sturgeon management efforts in Oregon and Washington concentrate on the Columbia River system, which forms a major portion of the boundary between the two states. Following the collapse of white sturgeon stocks in the late nineteenth century, the Columbia River commercial sturgeon fishery underwent numerous regulatory changes. These began with a ban on sturgeon sales from 1899 to 1908. Beginning in 1909, the rules were relaxed to permit the sale of sturgeon, although such sales were limited to salmon seasons only. Sturgeon setlines were allowed in the mid-1970s, but were phased out by the mid-1980s. Targeted sturgeon gill net seasons replaced the setline seasons in the mid-1980s, but were subsequently eliminated in 1989. Annual catch guidelines were adopted beginning in 1993 (Joint Columbia River Management Staff [JCRMS] 2000, 2001a).

Since 1989, lower Columbia River white sturgeon fisheries (below Bonneville Dam), both commercial and recreational, have been managed for optimum sustained yield (OSY), a management model designed to optimize catch while allowing the lower Columbia white sturgeon population to rebuild (Beamesderfer 1999; JCRMS 2001a). Management actions taken between 1985 and 1996 to restrict catch rates consistent with the OSY principle included (1) increasing the minimum size limit in recreational fisheries; (2) lowering the maximum size limit in all fisheries; (3) reducing the daily and annual catch limits for recreational fisheries; and (4) adopting catch guidelines for commercial fisheries (JCRMS 2000, 2001a).

During the period from 1985 through 1996, size and catch limits changed frequently. In 1985, sport regulations permitted a daily catch limit of three fish between 36 and 72 inches, with no annual catch limit. By 1996, sport regulations permitted a daily catch limit of only one fish between 42 and 66 inches, with a 10–fish annual limit. Largely because of the increasingly restrictive regulations, sport catch declined from a peak of 62,400 fish in 1987 to a low of 17,300 fish in 1990. Since 1992 sport catch has ranged between 33,500 and 45,100, in response to a rebounding population and continuing regulatory changes. Concurrently, commercial catch declined from a peak of 11,600 in 1986 to a low of 3,800 in 1991 because of reductions in fishing opportunities (JCRMS 2000, 2001a).

In October 1996, the Directors of the Oregon Department of Fish and Wildlife (ODFW) and the Washington Department of Fish and Wildlife (WDFW) signed the first Joint State Agreement on sturgeon fishing; the management plan was titled, "The Olympia Accord on Columbia River Sturgeon Fishery Management." It contained a variety of fishery regulations, including: (1) size limits for recreational and commercial fisheries; (2) daily and annual catch limits for recreational anglers; (3) gear restrictions for recreational fisheries; and (4) the allowance of target sturgeon seasons in the commercial fishery. The maximum size limit for white sturgeon, which had been reduced twice from 72 inches to 66 inches in 1993, was further reduced to 60 inches in 1997. However, the cornerstone of the plan was the adoption of a three-year average catchable number to ensure that the fisheries did not exceed OSY limits. An annual catchable number of 67,300 white sturgeon was initially adopted for the period 1997 to 1999, with an allocation of 80% (53,840 fish) for recreational fisheries and 20% (13,460 fish) for commercial fisheries. Other management actions enacted included a 9 -3/4 inch maximum mesh size limit to reduce the capture of oversize sturgeon in commercial fisheries and a 9-inch minimum mesh size limit for targeted commercial sturgeon fisheries to minimize bycatch of non-targeted species (JCRMS 2001a).

The Olympia Accord allowed for modifications if new information suggested that changes were warranted. During the spring of 1999, abundance estimates from tagging efforts in 1996 and 1997 were less than expected. Therefore, the catchable number was reduced to 50,000 beginning with the 1999 fisheries. The allocation of 80% for recreational fisheries and 20% for commercial fisheries remained unchanged (JCRMS 2001a).

Commercial catch of white sturgeon in fishing zones in the lower Columbia River is also subject to the framework of the Columbia River Compact, which is charged by congressional and statutory authority to adopt commercial fishing seasons and regulations. The Compact's membership includes the Oregon and Washington fish and wildlife agency directors, acting on behalf of the Oregon Fish and Wildlife Commission (OFWC) and the Washington Fish and Wildlife Commission (WFWC). In addition, the Columbia River treaty tribes have authority to regulate treaty Indian fisheries. When addressing commercial seasons for species under its jurisdiction, including sturgeon, the Compact must consider the effects of the commercial fishery on escapement, treaty rights, and sport fisheries, as well as the potential impact on ESA-listed species. While the Compact has no authority to adopt sport fishing rules or seasons, it has an inherent responsibility to consider the equitable allocation of limited resources among users (JCRMS 2001b).

In February 2000, the directors of ODFW and WDFW agreed to extend the Joint State Agreement for an additional three-year period, from 2000 to 2002. Therefore, the lower Columbia river fishery continued to be managed under the new "Joint State Agreement on Columbia River Sturgeon Fishery Management." Commercial fishing also falls under the overall framework of the Columbia River Compact (Columbia River Compact 2000; JCRMS 2001a). Major tenets of the new management agreement included: (1) continuation of management based on an OSY approach; (2) absent significant update, annual catchable number averages of 50,000 for the three-year period; (3) allocation of 80% for recreational fisheries and 20% for commercial fisheries; (4) targeted commercial seasons as necessary to provide access to the allocation and maximize economic benefits consistent with conservation objectives; (5) a commercial size limit of 48 to 60 inches; and (6) a recreational slot limit of 42 to 60 inches, with a catch limit of one per day and 10 per year, plus a requirement that barbless hooks be used (Columbia River Compact 2000; JCRMS 2001a, 2001b).

The determination of the catch limit for white sturgeon is largely based upon surveys conducted by authorities designated under the Agreement to monitor stocks in the lower Columbia River system. Annual abundance estimates have been produced since 1989, with the exception of 1994. Table 4.9.1 shows the estimated abundance of catchable white sturgeon in the lower Columbia River from 1989 to 2001. In addition, general indices of abundance of sublegal (less than 42 inches)

Table 4.9.1 Estimated Abundance of Catchable White Sturgeon in the Lower Columbia River, 1989–2001*

Year	Total Length Interval (inches) 42–48	48–60	42–60
1989	32,500	16,800	49,300
1990	26,100	12,000	38,100
1991	32,900	11,700	44,600
1992	59,900	8,700	68,600
1993	85,000	14,200	99,200
1994	N/A	N/A	N/A
1995	143,200	59,000	202,200
1996	131,700	33,500	165,200
1997	123,700	33,400	157,100
1998	161,600	24,700	186,300
1999	116,800	17,600	134,400
2000	119,200	17,000	136,200
2001	100,200	22,400	122,600

Key: N/A = Not availabl3

* Source: Columbia River Compact (2002b)

and oversized (greater than 60 inches) sturgeon were believed to be strong as of 2001; the overall population of white sturgeon greater than two feet in length is believed to exceed 1 million fish (JCRMS 2001a, 2001b, 2002).

These abundance estimates indicate that the total number of catchable-size white sturgeon (42 to 60 inches) increased from fewer than 50,000 in 1991 to more than 200,000 in 1995, an increase of more than 400% (JCRMS 2000, 2001a). The average from 1995 to 2000 was 164,000 fish. The majority of the increase occurred in the 42- to 48-inch size group. There is evidence that the 1996 and 1997 harvestable population estimates were negatively impacted by a mass emigration of white sturgeon from the lower Columbia River (DeVore et al. 1999; JCRMS 2001a). Tag recoveries from outside of the Columbia River system indicated that the emigration began in 1996, and further data suggested that these white sturgeon returned to the lower Columbia River within a couple of years. However, it is believed that a second group of white sturgeon emigrated from the Columbia River in 1999 (JCRMS 2001a). The exact causes for these emigrations are unknown.

Actual catches of white sturgeon in the lower Columbia River have fluctuated under various management schemes during the past several decades. Table 4.9.2 shows the commercial and sport catches for the years 1977 to 2002, along with the percentages of catch attributable to commercial and sport fisheries.

As shown in Table 4.9.3, a comparison of actual catch compared to catch guidelines shows that the guidelines have been exceeded in both the commercial and sport fisheries in some years, while in other years actual catch has been below the catch guidelines (unit of measure = number of fish).

In recent years, fisheries authorities have addressed in two principal ways the issue of catches that exceeded catch guidelines. First, Joint Columbia River Management Staff have required that any overages (catch over the guidelines) from one year be applied to the following year's catch quota. For example, overages from the 2000 fisheries were applied to the 2001 catch guidelines, resulting in an adjusted 2001 catch limit of 39,500 white sturgeon for sport fisheries and 9,100 white sturgeon for commercial fisheries (JCRMS 2001b). Commercial landings in 2001 exceeded the 9,100 catch limit by 210 white sturgeon, and the sport catch exceeded the 39,500 catch limit by 700 white sturgeon (JCRMS 2002). According to a Joint Staff Report for the Columbia River Compact, based on a December 12, 2001 catch update, 2002 sport fisheries were to be managed for a catch target of 36,500, not to exceed 38,500, and

Table 4.9.2 Commercial and Sport Catch of White Sturgeon in the Lower Columbia River and Percentages, 1977–2002*

Year	Commercial+,†	Sport+	Total+	% Commercial	% Sport
1977	9,700	25,800	35,500	27	73
1978	9,800	30,400	40,200	24	76
1979	20,500	31,400	51,900	39	61
1980	9,400	27,000	36,400	26	74
1981	14,900	27,200	42,100	35	65
1982	11,600	25,100	36,700	32	68
1983	12,400	36,000	48,400	26	74
1984	17,500	42,000	59,500	29	71
1985	8,400	43,800	52,200	16	84
1986	11,600	49,800	61,400	19	81
1987	9,700	62,400	72,100	13	87
1988	6,800	43,100	49,900	14	86
1989	5,000	25,400	30,400	16	84
1990	5,300	17,300	22,600	23	77
1991	3,800	22,700	26,500	14	86
1992	6,200	40,100	46,300	13	87
1993	8,100	37,900	46,000	18	82
1994	6,400	33,500	39,900	16	84
1995	6,200	45,100	51,300	12	88
1996	8,400	42,800	51,200	16	84
1997	12,800	38,200	51,000	25	75
1998	13,900	41,600	55,500	25	75
1999	9,500	39,800	49,300	20	80
2000	10,900	40,500	51,400	21	79
2001	9,300	41,200	50,500	18	82
2002#	9,800	37,500	47,300	21	79

Key: + Unit of Measure = Number of fish.
† Includes Youngs Bay (1979–present) and other Select Area landings (1998–present).
# Preliminary.

* Source: JCRMS (2002).

commercial fisheries were to be managed for a catch target of 9,200, not to exceed 9,700 (Columbia River Compact 2002a).

Second, as the Joint Agreement allows, fishery managers have authority to adjust regulations as needed to comply with management guidelines. In 2001, for example, fishery managers implemented temporary rules that prohibited retention of sturgeon in some management zones once catch guidelines were met, and introduced more restrictive legal size limitations for specific sport fisheries. Fishery managers may also adjust seasons in both commercial and sport fisheries to reduce or increase fishing opportunities as necessary to comply with targets. Finally, regulators anticipated that additional mesh size restrictions might be also adopted to ensure that Select Area fisheries target salmon rather than white sturgeon (Columbia River Compact 2001; JCRMS 2001a, 2001b).

Data gathered during 2001 indicated that the overall quota of 50,000 white sturgeon might not be appropriate for future fisheries, and that additional catch reductions might be required for both sport and commercial fisheries (ODFW 2001b; JCRMS 2001a, 2001b). In the opinion of the Joint Columbia River Management Staff, abundance estimates for 1997 to 2000 suggested that the level of 50,000 catchable fish might be excessive. However, the staff's report noted contradictory evidence. Improved catch rates in 2001 as compared to the period 1997–2000 might have indicated an increase in abundance. In addition, the report noted that abundance estimates for 1999 and

Table 4.9.3 Commercial Catch of White Sturgeon by Season, Annual Sport Catch, and Comparisons to Catch Guidelines, 1993–2002*

Seasons	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002†
	Mainstem Commercial									
Winter	990	2,990	0	800	2,710	2,680	1,780	2,260	3,060	2,790
August	0	0	0	0	1,740	2,540	2,770	2,490	4,720	1,390
Early Fall	0	0	0	330	140	90	60	300	1,020	370
Late Fall	7,010	3,380	5,980	6,580	7,790	8,060	4,180	5,130	0	4,240
Mainstem Subtotal	8,000	6,370	5,980	7,710	12,380	13,370	8,790	10,180	8,800	8,790
	Select Area Commercial									
Spring/Summer	32	31	114	581	351	355	523	540	490	630
Fall	17	4	65	110	96	171	194	160	20	340
Select Area Subtotal	49	35	179	691	447	526	717	690	510	970
	All Commercial									
Commercial Total	8,100	6,400	6,200	8,400	12,800	13,900	9,500	10,870	9,310	9,760
Catch Guideline	6,000	6,000	8,000	8,000	13,460	13,460	10,000	10,000	9,100	9,800
	Lower Columbia Sport									
Sport Total	37,900	33,500	45,100	42,800	38,200	41,600	39,800	40,500	40,200	37,500
Catch Guideline	—	—	—	—	53,840	53,840	40,000	40,000	39,500	38,500

Key: † = Preliminary; sport catch projected for November 23 through December 31, 2002.

* Source: JCRMS (2002).

2000 are likely low because of changes in tagging operations during those years. Specifically, in 1999 and 2000 tagging operations occurred primarily during May and June, while previous tagging operations occurred from May through August. Estimates based on May and June tag groups are typically lower than abundance estimates based on July and August tag groups, and it was further noted that 1999 and 2000 tagging operations overemphasized the estuary component of the white sturgeon population, so that only a portion of the total populations was estimated. Tagging operations were expanded in 2001 to address this bias (JCRMS 2001a). In 2002, Oregon also reported that it was asking sport anglers in several coastal estuaries to cooperate in an ongoing sturgeon migration and residence study by returning tags with the date and location the fish was caught, the length of the fish, and whether it was kept or released (ODFW 2002).

Because of the contradictory evidence, because 2002 represented the end of the 2000–2002 Joint State Agreement, and because the 2001 abundance estimate was not yet available, fishery managers chose not to modify the catchable number or sport/commercial allocation for 2002 (JCRMS 2002). However, in more recent action the Oregon and Washington Fish and Wildlife Commissions decided to lower the number of white sturgeon that can be caught annually from 50,000 to 40,000 for the years 2003–2005. This plan may be modified if new information suggests that a change is warranted. The allocation between sport and commercial fisheries remains the same at 80% (32,000 fish) for sport fishing and 20% (8,000 fish) for commercial fisheries (Columbia River Compact 2002b).

White sturgeon fisheries also exist in the Columbia River upstream from Bonneville Dam. White sturgeon fisheries between Bonneville Dam and McNary Dam (Management Zone 6) consist of Treaty Indian commercial and subsistence fisheries, as well as non-Indian sport fisheries. Treaty Indian commercial fishing includes hook and line, setline, and gill net fisheries, while non-Indian fisheries are restricted to hook and line only. Treaty Indian fishers may take white sturgeon for subsistence purposes year-round (JCRMS 2001a).

White sturgeon stock assessments are conducted periodically in some reservoirs, or "pools," above Bonneville Dam, to monitor the effects of hydro-system mitigation activities

and OSY catch strategies. Population estimates are derived from mark-recapture efforts involving sampling with gill nets and set lines. Estimates in different pools are not measured in the same years, making direct comparisons difficult. Table 4.9.4 shows abundance estimates for white sturgeon between three and six feet in length for sampled pools in Management Zone 6 during surveyed years.

Similar to the lower Columbia River fishery, regulations in the Zone 6 management area developed and changed over a period of years. White sturgeon catch in Zone 6 peaked in 1987, with a commercial catch of 11,100 fish and a sport catch of 6,700 fish. In that year, concerns about increasing catch rates and declining white sturgeon abundance prompted the creation of a Sturgeon Management Task Force (SMTF). The SMTF, composed of representatives from Oregon, Washington, and the Columbia River treaty Indian tribes (Nez Perce, Umatilla, Warm Springs, and Yakama), reviewed the status of white sturgeon in the management area and recommended that (1) treaty Indian seasons be shortened; and (2) the minimum size limit in the sport fishery be moved up. These recommendations took effect in 1988. Treaty Indian setline seasons were reduced from 10 to 4 months, and sturgeon sales were generally limited to winter seasons. Sport fisheries adopted a two-fish daily catch limit and a 40- to 72-inch size limit restriction, which reduced sport catch by 40% (JCRMS 2001a).

Since 1991, catch guidelines recommended by the SMTF have entered into effect for both treaty Indian commercial fisheries and recreational fisheries in Zone 6. From 1991 to 1996, guidelines for treaty Indian commercial fisheries were 1,250 for Bonneville Pool, 300 for The Dalles Pool, and 100 for John Day Pool. Guidelines for recreational fisheries during this period were 1,350 for Bonneville Pool, 100 in The Dalles Pool, and 100 in John Day Pool. Management plans included providing treaty Indian subsistence catch accountability and limiting sturgeon sales in fisheries to levels consistent with the catch reduction plan. In 1994, retention of sturgeon in Zone 6 sport fisheries was prohibited for the first time when catch was projected to exceed SMTF guidelines. Such closures have been enacted every year since 1994; sport anglers may continue to fish for white sturgeon and then release them unharmed when catch guidelines are reached and retention is prohibited (JCRMS 2001a).

In 1997, the SMTF agreed to adopt pool-specific management with catch guidelines based on the OSY principle. These guidelines were designed to allow for adequate survival of juvenile sturgeon to increase the number of catchable and broodstock fish. After analyzing Zone 6 white sturgeon stocks, the states and tribes decided to reduce the maximum size limit to 60 inches, and established new OSY catch guidelines. Revised catch guidelines for treaty Indian commercial fisheries were 1,300 for Bonneville Pool, 400 in The Dalles Pool, and 1,160 in John Day Pool; sport fishery guidelines became 1,520 in Bonneville Pool, 200 in The Dalles Pool, and 560 in John Day Pool (JCRMS 2001a).

During the period 1998 to 2000, additional data from The Dalles Pool led to an increase in catch guidelines, to 1,000–1,200 for treaty Indian commercial fisheries and 600–800 for sport fisheries. In 2001, the guidelines were reevaluated and the SMTF agreed to a level of 1,100 for treaty Indian commercial fisheries

Table 4.9.4 Annual 3- to 6-foot Abundance Estimates by Pool in the Zone 6 Management Area of the Columbia River*

Bonneville Pool		The Dalles Pool		John Day Pool	
Years	Abundance Estimate	Years	Abundance Estimate	Years	Abundance Estimate
1976–78	5,400	1987	18,900	1990	2,200
1989	17,900	1988	6,300	1996	24,100
1994	19,800	1994	6,500	2001	13,900
1999	39,700	1997	46,800		

* Source: JCRMS (2002).

and 700 for sport fisheries (JCRMS 2001a). These guidelines were expected to remain constant in 2002 for Bonneville Pool and The Dalles Pool; however, based on the most recent population estimate, guidelines for John Day Pool for 2002 were reduced to 165 in the sport fishery and 335 in the treaty Indian fishery (Columbia River Compact 2002a). Sturgeon size limits were 48 to 60 inches in treaty Indian fisheries, 48 to 60 inches in sport fisheries in The Dalles and John Day pools, and 42 to 60 inches in Bonneville Pool sport fisheries (JCRMS 2001a).

Although the overall allocation is approximately 50-50 between sport and Indian fisheries, reservoir-specific guidelines are shaped to meet fishery demands. For example, the sport fishery is allowed a greater share of the Bonneville Pool catch while the Treaty Indian fishery receives a greater share of the catch in The Dalles and John Day pools. Treaty Indian fishermen may also continue to take sturgeon for subsistence purposes after commercial seasons have ended. The subsistence catch is monitored by the Yakama Indian Nation, and annually averages fewer than 300 sturgeon. This portion of the catch is not included in the catch guidelines (JCRMS 2001a). Table 4.9.5 shows the evolution of catch estimates and guidelines for Zone 6 fisheries during the period 1991 to 2002.

The guidelines and regulations outlined above demonstrate the careful and active management of the white sturgeon fishery in the Columbia River states, both in the lower Columbia River and in the Zone 6

Table 4.9.5 Annual Catch Estimates and Guidelines for Commercial and Sport Fisheries in the Zone 6 Management Area, 1991–2002*

	Bonneville Pool		The Dalles Pool		John Day Pool	
Year	Catch	Guideline	Catch	Guideline	Catch	Guideline
	Commercial Fisheries					
1991	1,000	1,250	460	300	40	100
1992	1,150	1,250	430	300	20	100
1993	1,420	1,250	500	300	10	100
1994	1,180	1,250	310	300	120	100
1995	1,420	1,250	310	300	310	100
1996	1,000	1,250	230	300	360	100
1997	1,850	1,300	500	400	1,260	1,160
1998	1,460	1,300	1,100	1,000–2,000	1,100	1,160
1999	1,280	1,300	1,050	1,000–2,000	760	1,160
2000	1,180	1,300	1,340	1,000–2,000	790	1,160
2001	1,287	1,300	1,499	1,100	759	1,160
2002+	432	1,300	1,138	1,100	322	335
	Sport Fisheries					
1991	2,270	1,350	200	100	150	100
1992	1,720	1,350	140	100	150	100
1993	2,310	1,350	160	100	140	100
1994	2,220	1,350	160	100	240	100
1995	1,370	1,350	50	100	90	100
1996	1,360	1,350	60	100	80	100
1997	1,470	1,520	180	200	480	560
1998	1,630	1,520	860	600–800	600	560
1999	1,240	1,520	690	600–800	400	560
2000	1,260	1,520	810	600–800	430	560
2001	1,430	1,520	660	700	220	560
2002+	1,334	1,520	715	700	154	165

Key: + Preliminary. Commercial catch in Bonneville Pool reflects catch through November 3, 2002; sport catch for Bonneville Pool reflects catch through October 31, 2002.

* Source: JCRMS (2002).

management area. It is important to note that the information summarized herein reflects the state of affairs as of late 2002; regulations and catch guidelines may very well undergo further review and adjustments. For the most current information on management and regulation of the Columbia River white sturgeon fisheries, readers should refer to the periodic reports of the Joint Columbia River Management Staff, the Columbia River Compact, and to updates on the administrative rules for the fisheries issued by the states of Oregon and Washington.

There is also some directed commercial fishing for white sturgeon in coastal marine waters. For example, Washington scheduled a fishery for white sturgeon from November 6 to November 30, 2001, in Willapa Bay, subject to an overall quota of 1,037 fish, including catches during earlier salmon fisheries (WDFW 2001b, 2001c).

Idaho

Catch-and-release angling restrictions have been in place for white sturgeon on the Snake River in Idaho since 1984 (Miller et al. 2001). There is no catch season for white sturgeon. Any white sturgeon that is caught may not be removed from the water and must be released immediately. Barbless hooks are required at all times (Idaho Department of Fish and Game 2000; Idaho Administrative Code IDAPA 13.01.11).

Montana

Montana has prohibited commercial and sport fishing for white sturgeon since 1979 (Miller et al. 2001). Take and/or possession of white sturgeon is illegal in Montana (Montana Fishing Regulations 2002-2003).

California

As discussed in Section 3.9, California has not allowed commercial catch of wild white sturgeon since 1917. The state also prohibits the purchase, sale, or possession of a whole sturgeon or any parts thereof, including eggs, in any place where fish are sold (California Fish and Game Code, Sections 7370, 8370–8403). There is an exception to this prohibition in the case of white sturgeon reared in approved and permitted aquaculture facilities in the state, which is described in greater detail in Section VI on Hatcheries and Commercial Aquaculture.

In freshwater fisheries, sport fishermen may take white sturgeon year-round, except for closures listed under special regulations. Recent closures have encompassed the Special North Coast District Sturgeon Closure (Humboldt, Del Norte, Trinity, and Siskiyou counties), where it is illegal to take any sturgeon at any time. In open areas, sport anglers may keep one fish between 46 inches and 72 inches (115–183 cm) per day. The sturgeon must voluntarily take the bait or lure in its mouth. No sturgeon can be taken by trolling or snagging. In addition, fish must be landed without use of a gaff, and no person can use any type of firearm to land a sturgeon (California Department of Fish and Game [CDFG] 2000a).

Marine sport fisheries are open all year, with the same size restriction, daily bag limit, and methods of take that apply to the freshwater sport fishery. Sturgeon may not be taken between January 1 and March 15 in the portion of San Francisco Bay that includes the following boundaries: a direct line between Point Chauncy (National Marine Fisheries Laboratory) and Point Richmond, the San Francisco–Oakland Bay Bridge and a direct line between Point Lobos and Point Bonita (CDFG 2000b).

4.10 Green Sturgeon

Directed take of green sturgeon is not as prevalent as that for white sturgeon. While the species is exploited commercially in some areas, its catch is banned in Canada and restricted in the United States. The species is more likely to be taken incidentally than intentionally.

Canada

Canada designated the green sturgeon as a species of Special Concern in 1987. In British Columbia, the only Canadian province in the species' range, catch or possession of green sturgeon is prohibited under the Federal Fisheries Act. Because of the "disagreeable" odor and taste of the species' flesh and roe, green sturgeon were not traditionally caught in directed commercial fisheries in British Columbia (Environment Canada 2001).

United States

The green sturgeon is not federally protected in the United States, although, as discussed in Section 3.10 above, in 2001 a petition was submitted to list the species under the ESA. Similar to white sturgeon, specific rules for its catch and management fall under the jurisdiction of Pacific coast states and treaty fisheries.

Alaska

Alaska classifies the green sturgeon as a commercial fish for purposes of taxation, and provides a species code for tax returns on landings (Alaska Department of Revenue 2001). However, there is not believed to be significant directed commercial or sport fishing for green sturgeon in the state.

California

California designates the green sturgeon as a Species of Special Concern (CDFG 1995). Commercial catch of the green sturgeon is prohibited in the Sacramento–San Joaquin River Basin. A small Native American subsistence fishery continues in the Klamath River, although catch figures are not available (Waldman 1999). There is not believed to be a directed sport catch for the species.

Oregon/Washington

Directed commercial fishing for green sturgeon is not permitted in the Columbia River system. Green sturgeon may, however, be taken incidentally during other commercial seasons such as white sturgeon fisheries, provided the level does not exceed levels observed in past fisheries. The commercial slot limit for green sturgeon in these fisheries is 48 to 66 inches (Columbia River Compact 2000). There are not believed to be directed sport fisheries for green sturgeon. However, the species may be taken during seasons for white sturgeon. Sport fishery regulations include a slot limit of 42 to 60 inches, one sturgeon per day and 10 sturgeon per year catch limits, and required use of barbless hooks (Columbia River Compact 2000). Table 4.10.1 shows commercial and sport catch of green sturgeon in the Columbia River from 1977 to 2002.

Table 4.10.1 Commercial and Sport Catch of Green Sturgeon in the Lower Columbia River, 1977–2002*

Year	Commercial	Sport	Total
1977	800	0	800
1978	1,700	0	1,700
1979	1,200	0	1,200
1980	1,700	0	1,700
1981	200	0	200
1982	800	0	800
1983	700	100	800
1984	2,700	100	2,800
1985	1,600	500	2,100
1986	6,000	400	6,400
1987	4,900	200	5,100
1988	3,300	100	3,400
1989	1,700	100	1,800
1990	2,200	100	2,300
1991	3,200	<100	3,200
1992	2,200	100	2,300
1993	2,200	<100	2,200
1994	200	100	300
1995	400	<100	400
1996	600	100	700
1997	1,600	<100	1,600
1998	700	100	800
1999	800	100	900
2000	1,200	<100	1,200
2001	300	100	400
2002+	200	<100	200

Key: + Preliminary.

* Source: JCRMS (2002).

V. Legal and Illegal Trade

North American paddlefish and sturgeon species have become increasingly prominent in recent domestic and international discussions regarding the caviar trade, particularly since concerns began to develop over the deteriorating situation in the Caspian Sea fisheries. These discussions have involved both the caviar trade generally and individual North American species specifically.

As described in previous sections, the commercial history of North American paddlefish and sturgeon has been characterized by brief periods of intense catch, followed by years of little or no commercial fishing and trade activity because of significant declines in stocks. Recent decades evidenced a lull in the trade of North American Acipenseriformes, attributable to depletion of the resource, the ready availability of caviar from foreign sources, and legal protections instituted to conserve several species.

Uncertainty over the future availability of caviar from the traditionally caviar-rich Caspian Sea region, however, has led to concerns that the lull in demand for, and trade of, North American Acipenseriformes has ended. As early as the mid-1970s, fisheries experts and conservationists noted declines in populations of all six Caspian Sea species, especially those considered most commercially valuable: the beluga (*Huso huso*), Russian (*Acipenser gueldenstaedtii*), and stellate (*Acipenser stellatus*) sturgeons. When the Soviet Union dissolved in 1991, economic troubles, political unrest, and a breakdown of law and order further affected the Caspian Sea fisheries and management efforts, leading to concerns that a complete collapse of the fishery was possible. One of the first indications of the renewed attention to trade of North American acipenseriform species came in 1992, when the Parties to CITES listed the paddlefish in Appendix II. In 1998, the Parties went further, placing all of the world's previously unlisted Acipenseriformes in Appendix II.

This section briefly reviews the global caviar market, to provide an overall context for the international trade environment and the role that North American species have played in it to date. It then reviews recent CITES decisions regarding paddlefish and sturgeon, the implementation of these decisions in the United States and Canada, and potential impacts to North American species as a result of shifting caviar markets and changes in the trade environment. It also discusses what is known about the legal domestic market for North American paddlefish and sturgeon products, as well as developments in international markets and trade in these species. Finally, it considers the extent of illegal trade in North American acipenseriform species, and how increased demand and trade pressures might affect their conservation and management.

Not all North American Acipenseriformes are commercially fished. Therefore, regarding legal trade, the focus herein falls heavily on a specific subset of species. In the United States, native Acipensiformes allowed in commercial trade include primarily the paddlefish, white sturgeon and shovelnose sturgeon. Canada limits commercial catch and trade of native species to the Atlantic sturgeon and lake sturgeon. There is no legal commercial trade of Gulf sturgeon, shortnose sturgeon, Alabama sturgeon, or pallid sturgeon, although there have been exports of these species for purposes of scientific research. Limited catch and trade of the green sturgeon is allowed in certain U.S. states, though the green sturgeon is considered the least commercially valuable of all North American acipenseriform species.

5.1 The Global Caviar Trade

Several products derived from sturgeon and paddlefish are involved in international trade. These include both caviar and non-caviar commodities (meat for consumption, live fish for the aquarium or ornamental industry, fry or fertilized eggs to supply aquaculture facilities).

Among these products, caviar has for many years been by far the most significant item in the international trade, measured both by volume and by value.

Although the caviar of at least 10 species of sturgeon and paddlefish has been reported in trade, available information suggests that the vast majority of caviar in the global market is derived from just a few species, overwhelmingly from the Caspian Sea basin. For example, in 1998 the stellate sturgeon (*A. stellatus*) accounted for 48 percent of the caviar in trade, and the Russian sturgeon (*A. gueldenstaedtii*) accounted for a further 31 percent (TRAFFIC International 2001). Together, caviar from these two species constituted almost 80 percent of the world market.

In addition, a small number of nations dominate the caviar trade at both the export and import levels. As of 1998, approximately 99 percent of the caviar supply came from seven countries, with more than 90 percent originating from the Caspian Sea basin. The largest suppliers were Iran (49 percent) and the Russian Federation (32 percent). Among consuming nations in 1998, 96 percent of the caviar was imported by just 12 countries, with 95 percent destined for EU nations, Japan, Switzerland, and the United States. More than 50 percent of the trade went to EU nations alone (TRAFFIC Europe 2001; TRAFFIC International 2001).

A comparison of statistics on worldwide catch and production (i.e., aquaculture) of sturgeon to import data from major consuming nations reveals two seemingly contradictory trends. Table 5.1.1 shows worldwide sturgeon catch and production per country between 1981 and 1995, and indicates a steady decline in the Caspian Sea fisheries that have long sustained the bulk of the caviar trade. Table 5.1.2 summarizes caviar imports by the United States, Japan, and the EU between 1990 and 2000. While the table does not reflect the total volume of the global caviar market, imports by these nations are believed to comprise the vast majority of the overall market. The table shows that imports of caviar during the early part of the 1990s actually increased, despite the drop in Caspian Sea sturgeon production, before also beginning a trend of significant decline toward the end of that decade.

The statistics in these tables, as well as data from other sources, illustrate several features of the global caviar trade that figure prominently in any discussion of trade in North American Acipenseriformes. The most salient points for the purposes of this report are as follows.

1. Although catch and production from the Caspian Sea declined significantly during the 1980s and 1990s, this fishery continued to overwhelm all other sources. According to the data shown in Table 5.1.1, annual catch and production of sturgeon evidenced a steady decline during the 1980s, from approximately 29,080 metric tons (31,988 tons; 63,976,000 pounds) in 1981, to 19,707 metric tons (21,678 tons; 43,356,000 pounds) in 1989. Worldwide catch and production of sturgeon dropped even further between 1990 and 1995, when it reached only 6,600 metric tons (7,260 tons; 14,520,000 pounds).

In 1981 Caspian Sea basin fisheries in the former Soviet Union (and subsequently Russia and the newly independent states of Azerbaijan and Kazakhstan), along with Iran, accounted for approximately 94 percent of worldwide catch and production. Non-Caspian Sea nations bordering the Mediterranean and Black seas accounted for approximately 3 percent, as did North America. In 1995, despite steep declines, Caspian Sea fisheries continued to produce approximately 75 percent of the world's total catch and production of sturgeon. Nations bordering the Mediterranean and Black seas accounted for approximately 13 percent of the 1995 world total, and a combination of North America and some European aquaculture operations produced approximately 12 percent (Raymakers 1999).

More recent statistics from 1998 indicate that catch and production of sturgeon in 1998 had dropped further to a total of 5,748 metric tons (6,323 tons; 12,645,600 pounds), of which 3,714 metric tons (4,085.4 tons; 8,170,800 pounds) came from wild sources and 2,034 metric tons (2,237.4 tons; 4,474,800 pounds) came from farmed sturgeon and paddlefish. Although the reported production of farmed sturgeon in 1998 almost doubled from a 1995 estimate of 1,142 metric tons (1,256 tons; 2,512,400 pounds), as of 1999 caviar production from commercial aquaculture remained at less than 15 metric tons (16.5 tons; 33,000 pounds),

Table 5.1.1 World Sturgeon Catch and Production per Country in Metric Tons, 1981–1995*

Country	Area	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Azerbaijan	Caspian Sea	0	0	0	0	0	0	0	218	120	73	108	106	98	95	100
China+	and other	—	—	—	—	33	135	167	160	135	—	20	40	40	27	47
Iran	inland waters	1,496	1,450	1,288	1,557	1,650	1,690	1,759	1,851	2,051	2,645	3,036	2,692	1,710	1,700	1,500
Kazakhstan	(e.g. Amur	0	0	0	0	0	0	0	3,181	3,181	3,130	1,766	1,705	1,109	635	563
Russian Federation	River Basin)	—	—	—	—	—	—	—	14,900	12,681	10,777	8,648	7,928	3,847	3,448	2,736
USSR		25,602	24,630	24,240	22,811	21,485	20,443	19,674	—	—	—	—	—	—	—	—
Total		**27,098**	**26,080**	**25,528**	**24,368**	**23,168**	**22,268**	**21,600**	**20,310**	**18,348**	**16,625**	**13,578**	**12,471**	**6,804**	**5,905**	**4,946**
Bulgaria	Danube	21	23	25	9	6	8	7	1	13	13	8	12	10	10	15
Romania	River Basin	16	16	35	25	19	11	8	17	7	0	0	2	2	2	9
Slovakia	and other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ukraine	inland waters	0	0	0	0	0	0	0	179	150	83	18	8	10	5	5
Total		**37**	**39**	**60**	**34**	**25**	**19**	**15**	**197**	**170**	**96**	**26**	**22**	**22**	**17**	**30**
Bulgaria		28	27	11	3	3	22	14	0	15	0	0	0	0	0	0
Romania	Mediterranean	54	48	41	56	37	31	32	18	19	4	15	13	17	6	5
Russian Federation	and Black Sea	—	—	—	—	—	—	—	520	492	895	891	878	904	1,012	673
USSR		850	1,074	1,330	1,434	1,287	1,374	1,317	—	—	—	—	—	—	—	—
Turkey		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ukraine		0	0	0	0	0	0	0	29	76	98	88	159	284	227	142
Total		**932**	**1,149**	**1,382**	**1,493**	**1,327**	**1,427**	**1,363**	**567**	**602**	**997**	**994**	**1,050**	**1,205**	**1,245**	**820**
Canada	Inland waters	120	111	104	145	110	30	25	253	286	253	233	252	267	281	294
Canada	Atlantic	21	10	9	10	43	20	20	18	51	3	18	14	181	100	2
Canada	Pacific	10	8	3	8	8	6	5	5	8	9	3	5	3	2	4
Estonia†	Inland waters	0	0	0	0	0	0	0	0	0	0	0	0	8	3	7
France†	Inland waters	0	0	0	0	0	10	10	10	10	10	10	20	140	150	160
Italy†	Inland waters	0	0	0	0	0	0	0	0	0	250	300	350	310	333	250
USA	Inland waters	502	898	614	598	640	662	692	0	0	0	0	0	0	0	0
USA†	Inland waters	360	321	321	480	232	546	519	314	232	277	201	220	217	147	147
USA	Atlantic	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0
Grand Total		**29,080**	**28,616**	**28,021**	**27,136**	**25,553**	**24,988**	**24,249**	**21,394**	**19,707**	**18,520**	**15,363**	**14,404**	**9,057**	**8,198**	**6,660**

Key: + Data from Chinese researcher, based on caviar production in the Amur River Basin.
† Aquaculture operations since the late 1980s; in some countries almost the entire production is from artificial breeding facilities.

* Source: Raymakers (1999).

Table 5.1.2 Reported Caviar Imports by Selected Major Importers, 1990–2000*

Volumes per Importer (metric tons)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Total	Avg.
USA	60	32	54	59	61	54	81	79	76	99	74	729	66
Japan	58	51	55	60	58	71	63	58	43	35	29	579	53
EU	154	210	202	264	190	201	150	146	138	130	80	1,865	170
Total	272	293	311	383	307	326	294	283	257	263	184	3,173	288

Total Value (US$1,000)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Total	Avg.
USA	5,280	3,072	5,400	6,726	6,222	6,372	8,019	12,166	15,245	22,287	19,309	110,078	10,007
Japan	14,732	12,342	14,575	14,520	13,944	18,886	21,924	17,052	15,975	11,205	11,866	167,021	15,184
EU	35,112	44,310	43,632	40,128	38,793	34,572	27,150	32,850	31,082	33,645	29,997	391,272	35,570
Total	55,124	59,724	63,607	61,374	58,959	59,830	57,093	62,068	62,302	67,118	61,172	668,371	60,761

Unit Value (US$/kg)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Avg. US$/kg
USA	88	96	100	114	102	118	99	154	196	225	259	141
Japan	254	242	265	242	249	266	348	294	374	352	404	299
EU	228	211	216	152	193	172	181	225	249	260	387	225

* Source: TRAFFIC Europe (2001).

which represented a small fraction of the amount of caviar produced from wild sources (TRAFFIC International 2001). In addition, it is clear that the Caspian Sea continued to comprise the bulk of catch and production, with figures measuring in the thousands of metric tons. As was seen in Section IV, commercial catch of native Acipenseriformes in North American fisheries are measured at most in the tens or hundreds of metric tons in even the largest commercial fisheries.

2. The decline in caviar trade is far lower proportionally than the decline in worldwide sturgeon catch and production over the past two decades. It is remarkable that, despite the steep and steady decline in worldwide catch and production of sturgeon throughout the 1980s and 1990s that was evidenced above, caviar imports remained strong into the mid-1990s. According to the data in tables 5.1.1 and 5.1.2, cumulative caviar imports by the EU, Japan, and the United States actually rose from 272 metric tons in 1990 to a peak of 383 metric tons in 1993, an increase of some 40 percent, despite a corresponding decrease in worldwide sturgeon catch and production during the same period of some 50 percent, from 18,520 metric tons in 1990 to 9,057 metric tons in 1993. It should be noted that imports of caviar by the major consuming countries did then decline in the late 1990s and 2000 when compared to the peak years of the early to mid-1990s (especially for EU nations), but overall, the statistics suggest that the level of international trade in caviar remained relatively stable during much of the 1990s despite the sharp decline in sturgeon catch and production.

3. The United States appears to be consuming an increasing proportion of the world's caviar production. As shown in Table 5.1.2, aggregate caviar imports among the major consumers declined by some 44 percent between 1995 and 2000, but that drop was accounted for by the EU and Japan. As documented previously by Hoover (1999), imports by the United States continued to increase during most of this period, peaking in 1999 at 99 metric tons. Although U.S. imports declined to 74 metric tons in 2000, that level was still some 34 percent greater than it had been in 1995. Whereas in 1995 the United States accounted for less than 17 percent of the market among major importing nations, in 2000 it accounted for slightly more than 40 percent.

4. The volume of the international caviar trade in recent years raises questions about the extent to which North American

sturgeon and paddlefish populations might be able to serve as substitutes for Caspian Sea caviar. As shown in Section IV, North American commercial fisheries produce a relatively limited amount of acipenseriform roe, and there are biological, ecological, and legal constraints on how much roe North American species can produce for the caviar trade. Examples of such constraints include the following: (1) previous experience in North American sturgeon and paddlefish fisheries, in which periods of intensive exploitation were followed by a collapse in stocks, suggests that North American acipenseriform populations are sensitive to high levels of catch; (2) many North American acipenseriform species and populations have yet to rebound from past overfishing, and their recovery has been constrained by habitat loss and degradation, their unique life history characteristics, and other biological and ecological factors; (3) although harvest of roe from some North American Acipenseriformes has increased in the past few years, the amounts produced remain a fraction of the overall volume of the caviar trade; (4) commercial aquaculture in North America has not yet developed to a point where it is producing enough roe to replace wild sources (see Section VI for more discussion on this topic); (5) therefore, at least in the near term, any increase in roe production from North American acipenseriform species would have to come from the wild; and (6) in response to concerns about the sustainability of catch levels, some jurisdictions are adopting more stringent regulations regarding catch of native acipenseriform species. As is detailed in Section 5.3, these factors may apply to individual North American species differently. Yet, cumulatively, it is difficult to imagine in the near term how North American roe production could increase enough to substitute for Caspian Sea sources in a global caviar trade that involves volumes several multiples above what North America is currently producing.

5. The declared value of caviar increased significantly during the 1990s, although increases in major import markets were uneven. As was shown in Table 5.1.2, the mean declared value of caviar imported into the United States was US$88 per kg in 1990, US$154 per kg in 1997, and US$259 per kg in 2000. Comparable values declared for these years for the EU were US$228 per kg in 1990, US$225 per kg in 1997, and US$387 per kg in 2000. Japan reported the highest mean values for caviar imports, at US$254 per kg in 1990, US$294 per kg in 1997, and US$404 per kg in 2000 (TRAFFIC Europe 2001). These figures would appear to indicate that demand for caviar remains strong in major markets, with prices increasing as the volume of supply available for imports has fallen. As is detailed below in Section 5.3, this phenomenon seems to apply to exports of North American caviar as well; reported values of exports of paddlefish and white sturgeon roe have increased over the past several years. Should it continue, this trend will likely have serious implications for management of North American acipenseriform species involved in the trade, as rising caviar prices increase the incentives for catch and trade.

6**. The different valuations of caviar in major import markets also illustrate that there is no established, global price for the commodity.** Prices appear to be dictated by what each individual market will bear. As is explained in more detail in Section 5.3, this holds true for North American exports of caviar as well. For example, valuations of reported U.S. exports of product identified by TRAFFIC as paddlefish caviar to Japan are significantly higher than are those to other countries or customers.

Unfortunately, long-term price and export trends for products from some North American Acipenseriformes are difficult to establish, because commercial international trade in these species did not come under regulation by CITES until 1998. Therefore, precise USFWS export data are available only since that time. The next section discusses how recent CITES decisions have affected the international caviar trade, and in particular the legal international trade in North American paddlefish and sturgeon products.

5.2 CITES and North American Acipenseriformes

The CITES Framework

Commercial international trade in many wildlife species is conducted within the framework of CITES.[1] As a general rule, species that are considered abundant and not threatened by trade are not listed in the CITES appendices, and trade in them is not regulated under the Convention. However, an exception to this general principle is made for so-called "look-alike" species. These are defined in Article II, paragraph 2(b) of the Convention as species that must be subject to regulation in order that trade in CITES Appendix II species of similar appearance be brought under effective control (CITES 2001b).[2]

Prior to 1997, only four of the world's 27 acipenseriform species were listed in the CITES appendices (TRAFFIC International 2001). Beginning in 1997, a series of decisions led to the listing of all of the world's Acipenseriformes in the CITES appendices, and consequently to changes in the prerequisites for international trade. A brief review of some of the major actions taken on behalf of sturgeon and paddlefish, and the reasoning behind them, follows.

CITES COP 10. At the Tenth Meeting of the Conference of the Parties (COP) to CITES, held in Zimbabwe in June 1997, Germany presented a proposal to include all previously unlisted acipenseriform species in the Convention's Appendix II. While some Caspian Sea species were listed on their own merits under Article II, paragraph 2(a) of the Convention,[3] in most cases the justification for the species' listings was the "look-alike" provision (i.e., because of the similarity of appearance of caviar from these species to that of the Caspian Sea species) (Gnam 1999). The impetus for the proposal was to curtail the illegal trade in caviar, and to ensure sustainable use and management of wild sturgeon species, particularly those of the Caspian Sea. The Parties to CITES adopted the proposal by consensus, but delayed its entry into effect until April 1, 1998, in recognition of the fact that preparations to implement the decision would require time (Gnam 1999; Raymakers 1999).

The principal effect of the 1997 decision as it related to North American Acipenseriformes was to place the Alabama sturgeon, pallid sturgeon, lake sturgeon (which had been listed in Appendix II from 1975 to 1983, then removed from the appendices), shovelnose sturgeon, white sturgeon, and green sturgeon under the umbrella of Appendix II's protections against illegal or unsustainable international trade. The shortnose sturgeon had already been listed as an Appendix I species in 1975, and the Atlantic sturgeon and paddlefish were listed on Appendix II in 1979 and 1992, respectively, under the criteria of Article II, paragraph 2(a). The 1979 decision to include the Atlantic sturgeon (including the Gulf sturgeon subspecies) on Appendix II had actually downlisted the species from a 1975 Appendix I designation to which Canada had taken a reservation (CITES 2001a).

The parties also adopted a resolution (CITES Resolution Conf. 10.12), that was later amended, recommending a specific set of actions to strengthen international and domestic regulations (in range states) regarding the catch and trade of Acipenseriformes. The most relevant of these recommendations as they related to North American sturgeon and paddlefish species included the following: (1) that Parties consider the harmonization of their national legislation related to personal exemptions for caviar, with the goal of limiting the personal effects exemption allowed under CITES to no more than 250 grams per person; (2) that range states of acipenseriform species included in Appendix II in accordance with Article II, paragraph 2(a) consider the feasibility of establishing annual export quotas; (3) that the CITES Secretariat consult with other pertinent bodies and experts to explore the development of a uniform marking system for acipenseriform parts and derivatives, as

[1] A general overview of CITES can be found in Section II of this report.

[2] The Convention text does not specifically mention similarity of appearance, but that is the common interpretation.

[3] Species listed under CITES Article II, paragraph 2(a) are defined in the Convention text as "all species which although not necessarily now threatened with extinction may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilization incompatible with their survival" (CITES 2001b).

well as aquaculture stocks; and (4) that the CITES Animals Committee consider including Acipenseriformes in its review of significant trade (discussed in greater detail below) (CITES 2001c).

The species listings and recommendations initially adopted at COP 10 directly affected the ways in which the United States and Canada would thereafter conduct international trade in native acipenseriform species. Perhaps most important, all exports of North American sturgeon and paddlefish, or their parts or derivatives, would have to meet CITES permitting requirements after April 1, 1998. The recommendation that range states adopt export quotas also raised some difficult issues for the United States and Canada, given the generally decentralized nature of species management in the two countries.

In a meeting organized in Moscow by the CITES Secretariat in January 1998, the United States and Canada met with the major caviar importing and exporting countries to discuss implementation of the 1997 CITES listing of Acipenseriformes. Some progress was made, but crucial issues such as the recommendation to establish export quotas for North American species remained unresolved. An issue of particular contention was with regard to the fact that neither the United States nor Canada normally use export quotas for sturgeon or (in the case of the United States) paddlefish products (USFWS 1998).

CITES Decision 11.58. At the Eleventh CITES COP, held in Gigiri, Kenya, in April 2000, the Parties took further actions to implement some of the recommendations made at COP 10. Specifically, the Parties adopted Decision 11.58, which stated: "Starting from 1 January 2001, range states should declare coordinated intergovernmental level annual export and catch quotas per basin, or biogeographical region where appropriate, for all commercial trade in specimens of Acipenseriformes. Parties should inform the Secretariat prior to 31 December of the preceding year. Parties that fail to inform the Secretariat will automatically be treated as having a zero quota for the following year" (CITES 2001d).

In February 2001, the CITES Secretariat issued a Notification to the Parties (No. 2001/005) concerning "Catch and Export Quotas for Acipenseriformes for 2001." It reiterated that in cases where two or more governments allow export of specimens originating in the same basin or biogeographical region, "…catch and export quotas should be coordinated at the intergovernmental level and communicated to the Secretariat for the Year 2001 before 31 December 2000. In the absence of such information it will be taken that the export quotas concerned are zero. Endemic species/populations/stocks exploited by a single country within its territorial waters are not covered by Decision 11.58 and need not be declared. The same applies to specimens produced through aquaculture" (CITES 2001e).

Decision 11.58 created a dilemma for the United States and Canada because the two countries manage catch of the species in question differently, and also because the issue of federal legal authority to establish nationwide quotas is unclear. In both countries, with the exception of federally protected species, individual states or provinces are charged with the responsibility to set catch quotas or restrictions on trade of native Acipenseriformes. The various limitations imposed by these jurisdictions may indicate to national CITES Management Authorities how much sturgeon and paddlefish product is likely to be produced in aggregate and made available for possible legal export. However, moving beyond that level of collaboration among state, provincial, and federal authorities to the establishment of national export quotas may not be legally feasible.[4]

[4] The USFWS has on several occasions asserted that it has no legal authority to impose export quotas for sturgeon and paddlefish. However, no specific legal authority has been cited as a bar to federal imposition of export quotas. TRAFFIC was unable, through its own research and attempts to clarify this position with the U.S. Department of Interior Office of the Solicitor, to verify that such a legal bar does exist (pers. comm., C. Hoover, TRAFFIC North America, August 2002). Further, there have been examples where the USFWS has imposed quotas on the import or export of wildlife, including species traditionally regulated by the states. One such example is box turtles of the genus *Terrapene*, when the genus was included on CITES Appendix II in 1995. FWS established an export quota for one year before imposing a zero quota, which remains in place. In fact, the zero quota was challenged in court and FWS' authority to impose that quota was upheld. It remains unclear how establishment of export quotas for sturgeon or paddlefish would be treated differently.

Additionally, there are five North American sturgeon species that currently share the same basin or biogeographical region: the Atlantic sturgeon, shortnose sturgeon, lake sturgeon, white sturgeon, and green sturgeon. The paddlefish is classified as extirpated in Canada; therefore, for CITES purposes it is treated as a species endemic to the United States (S. Lieberman, Chief, USFWS/DMA, *in litt*. to Willem Wijnstekers, Secretary General, CITES Secretariat, 2001). Of the aforementioned five sturgeon species, Canada allows commercial catch and international trade of Atlantic sturgeon and lake sturgeon, while the United States does not. Conversely, the United States permits the commercial catch and trade of white sturgeon and green sturgeon, which is currently prohibited in Canada. Neither country permits commercial trade of the shortnose sturgeon, and there is no documented international trade of green sturgeon (S. Lieberman, Chief, USFWS/DMA, *in litt*. to Willem Wijnstekers, Secretary General, CITES Secretariat, 2001; L. Maltby, Director, Species at Risk Branch, Canadian Wildlife Service [CWS], *in litt*. to Willem Wijnstekers, Secretary General, CITES Secretariat, January 25, 2001).

Thus, establishing intergovernmental export quotas for North American Acipenseriformes that are in trade is problematic, because the lists of species commercially fished in the United States and Canada are mutually exclusive. Further complicating the situation, the United States permits commercial catch and trade of paddlefish, but USFWS has noted that, as an endemic species, intergovernmental quotas cannot be established and the United States is not required to submit an export quota to the CITES Secretariat under the language of Decision 11.58 (S. Lieberman, Chief, USFWS/DMA, *in litt*. to Willem Wijnstekers, Secretary General, CITES Secretariat, 2001).

Notification 2001/005 addressed the issue of paddlefish by referring to CITES Resolution Conf. 10.12 (Rev.), stating: "Quotas communicated for endemic species and captive breeding operations (aquaculture) are…considered to be communicated in accordance with paragraph (f) of Resolution Conf. 10.12 (Rev.) and will be published separately with voluntary quotas for other species" (CITES 2001e). Paragraph (f) of the applicable resolution read, in turn, "that range States of sturgeon species included in Appendix II in accordance with Article II, paragraph 2(a), consider the feasibility of establishing annual export quotas for sturgeon specimens and, if they are established, communicate such quotas to the Secretariat" (CITES 2001c).[5] Therefore, because the paddlefish was included in Appendix II based on Article II, paragraph 2(a) of the Convention, the language of the resolution would indicate that the United States should consider the feasibility of establishing export quotas for the species.

Notification 2001/005 also included a paragraph inviting countries that do not use quotas as a means to limit exports, because of specific administrative or legal requirements applicable in those countries, to provide explanatory statements (CITES 2001e). In response, both the United States and Canada sent letters to the CITES Secretariat.

The United States' letter noted that commercial export is ongoing for only three native species of Acipenseriformes: paddlefish, white sturgeon, and shovelnose sturgeon. Because the paddlefish and shovelnose sturgeon are endemic species, the United States indicated that intergovernmental quotas cannot be set, and are not required, under the language of Decision 11.58. Furthermore, the United States noted that because many commercially traded products of paddlefish and white sturgeon can originate from captive propagation (e.g., live eggs, fry, caviar, meat), these products are exempt from the establishment of export quotas for aquaculture production. However, the United States attempted to provide the Secretariat with information on expected export levels from all sources, "in the spirit of open communication and data sharing" (S. Lieberman, Chief, USFWS/DMA, *in litt*. to Willem Wijnstekers, Secretary General, CITES Secretariat, 2001).

The United States' letter did not directly address the issue raised in Resolution Conf. 10.12 (Rev.), that, since the paddlefish is a species listed under Article II, paragraph 2(a),

[5] Although the language of the resolution referred to "sturgeon," it also defined sturgeon as "Acipenseriformes," thereby including the paddlefish.

the United States should consider the feasibility of establishing export quotas for it. The letter detailed what were termed "expected export levels" of native sturgeon and paddlefish species in a table. Table 5.2.1 duplicates the one sent by USFWS to the CITES Secretariat.

Canada's letter noted that Canada does not have catch quotas or other regulations for the affected species which are exported from the country, i.e., the lake sturgeon and Atlantic sturgeon. However, "to comply with the spirit of the decision," Canada provided figures for the Secretariat to use as export quotas for the year 2001. Canada also indicated possible levels of export of live animals, although this was not required under Decision 11.58 because all of these originated from aquaculture facilities (L. Maltby, Director, Species at Risk Branch, CWS, *in litt.* to Willem Wijnstekers, Secretary General, CITES Secretariat, January 25, 2001). The specific export levels indicated for each species are provided in Section 5.3.

CITES Resolution Conf. 11.13. Pursuant to another of the recommendations made in CITES Resolution Conf 10.12, at COP 11 the Parties also adopted Resolution 11.13 to establish a universal labeling system for the identification of caviar. Recognizing that illegal trade is a potential threat to acipenseriform species, and undermines efforts to manage sturgeon resources on a sustainable basis, Resolution Conf. 11.13 recommended the introduction of a uniform marking system for any container[6] entering international trade with more than the 249 grams of caviar allowed for personal use. Specifically, the recommendation called for a non-reusable label that would include, at a minimum, the grade of caviar (e.g., Beluga, Sevruga, Osetra), a standard species code, and a unique serial number for the shipment consisting of the two-letter code for the country of origin, the year of catch, and a unique number corresponding to the processing plant and lot identification number for the caviar. Along with specific recommendations for ways in which Parties and the CITES Secretariat can use such a labeling standard to guard against illegal trade, the resolution also recommended that Parties establish a registration or licensing system (or

Table 5.2.1 Expected Export Levels of Native Acipenseriformes from the United States*

Species	Commercial Trade Permitted?	Product	2001 Expected Exports	Source
Shortnose sturgeon	No			
Atlantic and Gulf sturgeon	No			
Lake sturgeon	No			
Pallid sturgeon	No			
Alabama sturgeon	No			
Shovelnose sturgeon	Yes	Meat Caviar	None+ 0.5mt	Wild Wild
Green sturgeon	Yes†	No documented Intl' Trade	None+	
White sturgeon	Yes†	Meat Caviar	3mt 22mt 3.5mt	Wild Captive Propagation Captive Propagation
Paddlefish	Yes	Caviar Meat Live Eggs	7.7mt 0.25mt 3mt 0.5mt 2 million	Wild Captive Propagation Captive Propagation Wild Captive Propagation

Key: + No specimens exported from the United States since taxon was listed in 1998.
† Although the United States permits commercial catch of this species, Canada has banned its possession and retention. Therefore, no intergovernmental catch or export quota can be established.

* Source: Susan Lieberman, Chief, USFWS/DMA, *in litt.* to Willem Wijnstekers, Secretary General, CITES Secretariat, 2001.

[6] Any tin, jar, or box into which caviar is directly packed.

both) for importers and exporters of caviar where legally possible. The resolution called for these procedures to be put in place for exports for 2001 (CITES 2001f).

A working group was formed to examine and clarify concerns related to the resolution, and in December 2000, the group submitted a report to the CITES Animals Committee emphasizing that the resolution was intended to apply only to commercial shipments and not personal effects. The original labeling requirement in Resolution Conf. 11.13 also applied only to exports, not re-exports. In April 2002, a recommendation was made to the Animals Committee to amend the resolution to expand the labeling requirement to explicitly cover re-exports as well (CITES 2002a). A new resolution adopted at COP 12 in 2002 does call for a labeling system to apply to re-exports and also calls for Parties to implement labeling systems for domestic trade as well. This resolution was scheduled to come into effect in early 2003 (pers. comm., Craig Hoover, TRAFFIC North America, December 2002).

There is some hope that clear guidelines for universal labeling will lead to better trade controls and assist efforts to ensure that consumers are not buying caviar obtained outside of legal channels (Raymakers 2001). The type of uniform labeling standard envisioned under CITES Resolution Conf. 11.13 could potentially benefit North American sturgeon and paddlefish in trade. Intentional mislabeling of North American caviar as Russian product is a law enforcement concern that became particularly evident after a U.S. caviar company and several individuals were convicted for the practice, and received the largest fine in the history of U.S. wildlife law enforcement as well as substantial prison sentences. This case is discussed in greater detail in Section 5.4. Of course, many questions remain to be addressed about how such a system could work within the state and provincial management structures of the United States and Canada, where fishermen and commercial aquaculture ventures operate under a variety of regulatory regimes. In addition, while a universal marking system could be extremely helpful, it is only one of many steps necessary to curb illegal caviar trade.

Although no universal labeling system covering all major importing and exporting countries and acipenseriform species in trade had been implemented as of the summer of 2002, some progress has been made. For example, Romania has been implementing a labeling system since 2001. Based on CITES provisions adopted at COP 11, an EU regulation in effect since January 2002 now prohibits the importation of unlabeled caviar. Several other countries, including Bulgaria, China, Iran, and Russia, have also provided the CITES Secretariat with their labeling regimes. Some countries started to implement the regimes in 2002 in order to comply with Resolution Conf. 11.13 and thereby be allowed to export their caviar to the EU (pers. comm., C. Raymakers, TRAFFIC Europe, August 2002). Presumably, U.S. or Canadian exports of caviar from native acipenseriform species could be prohibited if these countries do not also come into compliance.

CITES Significant Trade Review. The Significant Trade Review process was established under CITES Resolution Conf. 8.9 to assess the Parties' compliance with the conditions for trade in Appendix II species, in particular the implementation of non-detriment findings made prior to issuing export permits in countries of origin. This ongoing project aims to identify taxa that may be adversely affected by international trade at either the global or local level. Surveys of species identified for possible review are submitted to the CITES Animals Committee, which then creates a list of "candidate species." Once a species is approved, consultants compile detailed reviews incorporating both biological and trade data, and the Animals Committee then assigns the species to one of three recommended categories: (1) species for which the available information indicates that the provisions of Article IV of the CITES convention are not being implemented; (2) species for which it is not clear whether the provisions of Article IV of the Convention are being implemented; and (3) species for which the level of trade is evidently not a problem. The Animals Committee uses the information to assist in its subsequent country or species-specific recommendations of appropriate measures to adequately maintain and conserve targeted

species in their native range (Anon. 2001c; TRAFFIC International 2001; CITES 2002b).

CITES Resolution Conf. 10.12 of 1997 recommended that all Acipenseriformes be considered for review. In 2000, TRAFFIC, in cooperation with the IUCN/SSC Wildlife Trade Programme, agreed to undertake a review of 10 Appendix II species of sturgeon and paddlefish that are subject to significant levels of international trade. The first two North American species reviewed were the North American paddlefish and the lake sturgeon. The information received helped to frame issues for discussion at the CITES Animals Committee meeting in December 2000, and provided a valuable body of knowledge for those interested in sturgeon conservation and management. Both the paddlefish and lake sturgeon were recommended at that time for Category 2.

In April 2002, however, the Animals Committee concluded that Canada's answers to several questions and recommendations regarding the Canada population of lake sturgeon were insufficient. The failure to supply a sufficient response led the Committee to move the Canada population to Category 1, until Canada complies with the questions and recommendations posed to it. At the time of this writing, the CITES Secretariat was still awaiting Canada's response. If Canada responds in a way that satisfies the Animals Committee, it is anticipated that the species will be moved to Category 3 (pers. comm., Craig Hoover, TRAFFIC North America, September 2002).

In 2001, TRAFFIC again worked with the IUCN/SSC Wildlife Trade Programme and the CITES Secretariat to review three more North American Acipenseriformes: the Atlantic sturgeon, shovelnose sturgeon, and white sturgeon. Draft reviews were sent to the CITES Secretariat in January 2002, and in April 2002 the Animals Committee recommended placement of the white sturgeon in Category 3. Because of lingering questions about their status in trade, the Atlantic sturgeon and shovelnose sturgeon were recommended for split classifications. The Atlantic sturgeon was recommended for Category 2 / 3, and the shovelnose sturgeon for Category 1 / 2 (CITES 2002c). It is uncertain whether any further North American acipenseriform species will be reviewed, especially because all of those that figure prominently in trade have now been covered.

5.3 Legal Trade

With the above introduction to the global caviar trade, and with the CITES framework for trade in Acipenseriformes in mind, this section examines recent levels of legal trade in North American sturgeon and paddlefish, both domestically and internationally. As previously noted, in the United States, there is no legal catch or trade of the endemic Gulf sturgeon, Alabama sturgeon, and pallid sturgeon. The United States also prohibits any catch or trade of domestic stocks of Atlantic sturgeon or shortnose sturgeon, and no U.S. state currently allows commercial catch of lake sturgeon. U.S. domestic trade of green sturgeon is not considered significant; there are no documented export markets. Canada prohibits commercial catch and trade of domestic stocks of shortnose sturgeon, white sturgeon, and green sturgeon. Thus, the North American acipenseriform species that figure significantly in domestic and international trade are the paddlefish, shovelnose sturgeon, and white sturgeon in the United States, and the lake sturgeon and Atlantic sturgeon in Canada. (Table 2.3.1 earlier in this report provided an overall summary of the current domestic and export trade status of native stocks of North American Acipenseriformes in their range countries.)

Although the list of Acipenseriformes for which the United States and Canada permit commercial catch and trade from indigenous stocks is mutually exclusive, there is some trade between the two countries involving these species. The United States has long been a market for Atlantic sturgeon and lake sturgeon products from Canada, and Canada has served as a market for white sturgeon and, to a lesser degree, paddlefish products from the United States. Therefore, it would not be accurate to say that either country prohibits trade in these species altogether. Each country defines the legality of trade in domestic and export markets for its own acipenseriform

stocks, and regulates trade between the two countries through CITES. An overview of general CITES permitting requirements in the United States and Canada is provided in Box 5. How specific permitting requirements have applied to exports of various North American Acipenseriformes in recent years is discussed in the species summaries below.

Atlantic Sturgeon

The United States and Canada manage trade of Atlantic sturgeon differently. Canada allows catch of native stocks of Atlantic sturgeon, subject to catch quotas and other regulations. The United States prohibits all commercial catch and trade involving domestic stocks. The only U.S. trade in the species originates from the Canadian fisheries.

Canada

The primary product of Canadian Atlantic sturgeon fisheries is meat. It was believed historically that sustaining a caviar industry in Canada's Atlantic sturgeon fishery was difficult because of the uncertainty of spawning runs (NMFS/USFWS 1998). As was discussed in Section IV, the largest contemporary Atlantic sturgeon fishery in Canada—in Quebec's St.

BOX 5. General CITES Permitting Requirements Iin the United States and Canada

Commercial international trade in CITES Appendix II species is allowed only if export permits are obtained. Provision of such permits is subject to findings by national Management Authorities that trade is not detrimental to the species' survival in the wild, and that the species to be exported was legally acquired.

In the United States, USFWS is the primary agency responsible for CITES implementation. The USFWS Division of Management Authority (DMA) processes applications for CITES permits and makes the findings of legal acquisition necessary for the exportation of products or specimens covered by the Convention. The Division of Scientific Authority (DSA) assesses whether or not exports are detrimental to the survival of CITES-listed species, and is responsible for all scientific findings required under the Convention.[7]

The Canadian permit system for exports of CITES-listed wildlife species differs somewhat from that of the United States. Similar to the United States, in Canada jurisdiction over wildlife management is divided among the federal, provincial, and territorial governments. However, whereas U.S. CITES export permits are issued exclusively by USFWS, CITES management in Canada is shared among the federal, provincial, and territorial governments. The Canadian National CITES Management Authority is part of the Canadian Wildlife Service (CWS), within Environment Canada. In addition, there is a Management Authority within the federal Department of Fisheries and Oceans (DFO) and 12 provincial and territorial Management Authorities.

CWS issues export permits for species not regulated by the provinces or territories or, when necessary, on behalf of the province. DFO is responsible for issuing export permits for species covered by the federal Fisheries Act. These include marine mammals, fish, and marine invertebrates. DFO issues permits from regional offices across the country, coordinated by the CITES Administrator located in Manitoba. DFO has begun issuing multiple-use permits, which are pre-authorized permits given to industries to complete. A limited number of permits are provided to industries (primarily sturgeon processors) and copies must be returned to DFO. DFO does not handle CITES import permits, and has no enforcement powers; those matters remain with CWS.

Sources: Gnam (1999); CITES (2000); Environment Canada (2000); pers. comm, P. Hall, DFO, September 2001; pers. comm., E. Cooper, TRAFFIC North America Canada Representative, August 2002.

[7] The names of these two offices changed recently. Prior to the year 2000, they were referred to as the Office of Management Authority (OMA) and the Office of Scientific Authority (OSA), respectively.

Lawrence River—is now subject to maximum legal size limits designed to protect sexually mature fish. Caron and Tremblay (1999) also noted that sexually mature adult sturgeon are believed to use the deepest parts of the estuary in sectors that are not regularly exploited by commercial fishermen, and are largely absent from recent capture records. Commercial catch is limited in the smaller Atlantic sturgeon fishery in the Maritime Provinces, currently consisting of only a few licensed fishermen in a "sunset" fishery (i.e., the fishery will close when current license holders cease fishing because no new licenses are being issued) (Anon. 2001a).

Domestic trade. Between 1997 and 2000, Canada reported the cumulative catch of approximately 242.8 metric tons (242,780 kg; 534,116 pounds) of Atlantic sturgeon in the Quebec and Nova Scotia/New Brunswick fisheries (Anon. 2001a). During the same period, an examination of Canadian export data showed that Canada reported a total export of approximately 47.6 metric tons (47,647 kg; 105,051 pounds) of meat to various importing countries. The discrepancy between catch and export data may indicate a degree of domestic demand. However, because it is not possible to make a direct comparison between the catch and export figures (catch figures measure whole fish, while the exports record only the weight of the meat), TRAFFIC was unable to quantify the extent of the domestic market.

Export markets. In response to CITES Notification 2001/005, Canada submitted the following figures for the CITES Secretariat to use as export quotas for 2001: 58,000 kg of meat and 500 kg of caviar (L. Maltby, Director, Species at Risk Branch, CWS, *in litt*. to W. Wijnstekers, Secretary General, CITES Secretariat, January 25, 2001). Non-detriment findings for wild-caught sturgeon products are based on their being within sustainable catch limits, as defined by applicable quotas (Anon. 2001a).

For many years the largest importer of Canadian Atlantic sturgeon products has been the United States (Anon. 2001a). This may remain the case; however, the ASMFC recommendation that imposed a moratorium on U.S. catch and trade of Atlantic sturgeon, and parallel state actions to ban catch and possession of the species, may have eliminated some of the market. For example, responding to the 2000 CITES Significant Trade Review regarding Atlantic sturgeon, Canada reported that declining catches in the Saint John River, New Brunswick in 1999 and 2000 were largely believed to be the result of the closure of particular U.S. markets to Atlantic sturgeon imports (Anon. 2001a). Other importing nations for Canadian Atlantic sturgeon meat were France and Israel. A summary of Canadian exports of Atlantic sturgeon products in recent years is shown in Table 5.3.1.

Canada also indicated a possible export of 1,000 kg of live Atlantic sturgeon (L. Maltby, Director, Species at Risk Branch, CWS, *in litt*. to W. Wijnstekers, Secretary General, CITES Secretariat, January 25, 2001). Actual export levels for the period between 1997 and 2000 show the transfer of live specimens of Atlantic sturgeon to the United States, Italy, Germany, and Austria. These exports were not reported by weight, so it was not possible to determine how they might match against the suggested export quota reported for 2001. All of the reported exports came from New Brunswick; non-detriment findings were based on the fact that they had originated from live-capture breeding operations, and did not represent take from wild stocks (Anon. 2001a). There were no live exports from Quebec during this period. A summary of these exports are shown in Table 5.3.2.

The United States

The United States does not permit commercial catch or trade of Atlantic sturgeon from domestic stocks. TRAFFIC found only one record of a noncommercial export for scientific research purposes between 1998 and 2001, a shipment of three specimens to Germany in May 1999 (TRAFFIC analysis of USFWS Law Enforcement Management Information System [LEMIS] data, February 19, 2002).

Gulf Sturgeon

There is no legal commercial trade of Gulf sturgeon, domestic or international. TRAFFIC found only one record of an export for scientific research purposes between 1998 and 2001, a shipment of three specimens to

Table 5.3.1 Canadian Commercial Atlantic Sturgeon Export Summary, 1996–2000 (Product from Wild Sturgeon Only)*

	CITES Export Permits Issued	Product	Cumulative Weight of Commercial Export	Destination Market	Provincial Catch Quota and/or TAC
1996	8	Meat	49,477 lb (22,645 kg)	United States	Quota/TAC system not in effect
1997+	2	Meat	40,891 lb (18,545 kg)	United States	Quebec: 145,530 lb (65,488 kg) quota/TAC 6,015 fish; Nova Scotia/ New Brunswick: No quota or TAC set by provinces
1998†	4 1 1	Meat Meat Body	17,589 lb (7,959 kg) 66 lb (42.67 kg) 28 lb (12.6 kg)	United States France Israel	Quebec: 128,067 lb (57,630 kg) quota/TAC 5,297 fish; Nova Scotia/ New Brunswick: No quota or TAC set by provinces
1999#	1 2	Meat Meat	14,350 lb (6,508 kg) 20,152 lb (9,160 kg)	United States Israel	Quebec: 128,067 lb (57,630 kg) quota/TAC 5,297 fish; Nova Scotia/ New Brunswick: No quota or TAC set by provinces
2000‡	3 N/A£	Meat Caviar	12,003 lb (5,432 kg) 1 lb (0.45 kg)	United States United States	Quebec: 115,261 lb (51,867 kg) quota/TAC 4,767 fish; Nova Scotia/ New Brunswick: No quota or TAC set by provinces

Key: + Records indicate that both of these exports originated from the Quebec fishery.
† Records indicate that the four meat exports to the United States originated from the Quebec fishery. The exports to France and Israel originated in the Nova Scotia/New Brunswick fishery.
# Records indicate that the one export of 14,350 lb to the United States originated from the Quebec fishery. The exports to Israel originated in the Nova Scotia/New Brunswick fishery.
‡ Records indicate that all three meat exports originated from the Nova Scotia/New Brunswick fishery.
£ No separate permit—exported on the same permit as a shipment of meat.

* Sources: Anon (2001a); P. Hall, DFO, *in litt.* to TRAFFIC North America, September 28 and November 8, 2001.

Germany in May, 1999. This export was recorded as occurring on the same day that the three specimens of Atlantic sturgeon mentioned above were shipped, and involved the same export applicant and importing party (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

Shortnose Sturgeon

The United States does not permit commercial catch or trade of shortnose sturgeon, and TRAFFIC did not find any records of exports for scientific purposes (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002). Canada also does not permit commercial trade of shortnose sturgeon. There have been exports for scientific purposes in recent years, but the number of these is believed to be very small (pers. comm., P. Hall, DFO, December 2001).

Paddlefish

The United States is the only source of paddlefish products from native stocks. There is demand for U.S. paddlefish roe, meat, and other products (fertilized eggs, fry, live fish), both domestically and internationally. In addition, some countries to which the United States exported live eggs or fry in previous years have recently begun to submit export quotas of their own for some products derived from paddlefish.

Domestic trade. While the full extent of the domestic market for paddlefish is not known (such internal trade is not closely tracked or regulated), it is believed that the primary product in trade is caviar processed from paddlefish roe. In the spring of 2001, paddlefish roe brought fishermen US$40 to US$50 per pound in Tennessee, and processed caviar sold by small domestic producers sold

Table 5.3.2 Canadian Exports of Atlantic Sturgeon (Hatchery-Reared Live Fish), 1997–2000*

	Total CITES Export Permits Issued	Commercial Export of Product	Scientific Research Export of Live Animals	Live Animal Exports/Purpose Omitted	Comments
1997	1	0	1	0	1000 fingerlings to Austria. Permit issued for captive bred stock, exported for scientific research.
1998	5	0	5	0	2 research exports totaling 600 hatchlings: 100 to Italy, 500 to Germany. 2 research exports totaling 110 fingerlings to the United States. 1 export of 4,500 ~1-month old fry for research to Germany.
1999	3	0	0	3	1 export of 4,000 fertilized eggs to Germany; three 50g jars of caviar shipped on permit. 1 export of 6,000 sack fry to the United States. 1 export of 2,800 live two-month old fry to the United States.
2000	3	0	0	3	2 exports, each of 1,300 live Larvae, to the United States. 1 export of 500 live larvae to Italy.

* Source: P. Hall, DFO, *in litt.* to TRAFFIC North America, September 28 and November 8, 2001.

for US$9.50 to US$10 per ounce (approximately US$150 to US$160 per pound). In some domestic markets it was reported to command as much as US$15 to US$16 per ounce (TRAFFIC interviews with Tennessee fishermen/wholesalers/retailers, 2001). A TRAFFIC review of commercial Internet sites in 2002 found paddlefish caviar advertised at US$9.90 to US$12 per ounce (US$159.20–US$192 per pound; US$ 350.25–US$422.40 per kg).[8] There is also a small domestic market for paddlefish meat. While the amount of paddlefish roe caught would indicate that enough fish are being taken to supply at least a regional meat market, the true market appears to be for the roe.

As described in Section 4.4, states that allow commercial catch of paddlefish include Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee (Mississippi's fishery is closed during the roe season). Some of the markets for paddlefish roe may be local. However, much of the paddlefish roe produced in commercial fisheries is believed to be exported out-of-state. In addition, Montana and North Dakota are encouraging the consumption of locally produced paddlefish caviar as a management strategy, through the establishment of nonprofit corporations that process and sell paddlefish roe taken in sport fisheries. A portion of the net proceeds from the sale of Montana and North Dakota's paddlefish roe are directed to further paddlefish research and management, as well as community-based grant programs to benefit local priorities (L. Peterman, Administrator, Fisheries Division, Montana Fish, Wildlife and Parks, *in litt*. to Teiko Saito, USFWS/OMA, August 21, 2000; G. Power, Fisheries Division, North Dakota Game and Fish Department, *in litt*. to Teiko Saito, USFWS/OMA, August 22, 2000).

An analysis of domestic roe production from paddlefish compared to caviar import statistics suggests that paddlefish roe constituted a relatively small share of the overall caviar market in the United States into the late 1990s. For example, in 1999 the cumulative legal

[8] Because prices are not static, and TRAFFIC does not endorse individual retail operations, the specific Web sites reviewed are not included here. Readers interested in the subject can review which retailers are selling paddlefish roe, and current prices, through a Web search using the key words "caviar" and "paddlefish."

reported harvest of roe for the states of Illinois (423 pounds), Kentucky (7,165 pounds), and Tennessee (3,096 pounds) amounted to a total of 10,684 pounds (4,807 kg; ~4.8 metric tons). If that amount were doubled, tripled, or even quadrupled to account for the lack of harvest data available from other states, likely shortfalls in the amount of roe reported by commercial fishermen, and caviar from sources such as the Montana and North Dakota roe donation programs, the amount of paddlefish caviar produced domestically still would not have nearly approached the volume of recorded imports of caviar for 1999, which totaled 99 metric tons (TRAFFIC Europe 2001).

Unfortunately, the lack of complete and contemporary data on paddlefish roe harvests in some U.S. states in recent years has made it impossible to accurately estimate the total current volume of U.S. paddlefish roe production, and therefore the full volume of the domestic market. It should be noted that significantly higher paddlefish roe harvests reported from 2000 to 2002 in states where figures are available suggest that domestic production of paddlefish caviar has increased substantially (part of the increase may be accounted for simply by more stringent reporting requirements and improved enforcement). As detailed in Section 4.4, Tennessee reported the harvest of 26,354 pounds of roe in 2000 and a preliminary estimate of 21,092 pounds of roe in 2001; Kentucky reported the harvest of 20,179 pounds of roe in 2000, 21,064 pounds in 2001, and 15,163 pounds of roe for the months from March through November 2002; Illinois reported the harvest of 2,292 pounds of roe in 2000 and 607 pounds of roe in 2001; and Arkansas reported the harvest of some 13,362 pounds of roe in 2002. It may be that the percentage of the U.S. caviar market being served by domestic paddlefish roe has increased. However, making a precise determination is not possible pending the availability of further data on roe harvests, current volumes of caviar imports, and the amount of domestic roe being exported.

Export Markets. Export records suggest that the focus and volume of the external market for North American paddlefish products shifted significantly beginning in 2000. Between 1995 and 1999, the commodities derived from paddlefish that were most frequently exported from the United States were live products, predominantly viable eggs or fry. There also appeared to be some exports of live fish for the aquarium or ornamental fish trade. Beginning in 2000, caviar became the predominant export commodity; however, it is worth noting that the level of caviar exports fell well within the parameters of the anticipated exports reported by USFWS to the CITES Secretariat in 2001, in response to CITES Decision 11.58.

In 1995, five shipments totaling 87,000 unspecified units identified as “eggs” were reported in USFWS export records, which TRAFFIC identified as most likely being live eggs based on their low valuation. There were also 10 shipments of “live” product, totaling 32,104 unspecified units that may have included live eggs, fry, or fish. In 1996 there were three exports totaling 40,000 “eggs,” as well as 16 “live” shipments totaling 80,464 live eggs, fry, or fish. In 1997, six exports totaling 187,000 “eggs” were reported, as were 11 exports totaling units of 235,300 “live” eggs, fry, or fish. In 1998, reported exports included two shipments totaling 180,000 “eggs,” and six shipments totaling 23,440 unspecified “live” units. In 1999, there were no reported exports of “eggs,” but there were four exports totaling 245,000 units of “live” product. Markets for these products included Asia (China, Japan, Taiwan), Europe (France, Great Britain, Italy, Romania, Greece, Hungary, Germany, Russia), Israel, and Mexico. Small commercial shipments of meat were also exported to Canada during this period. The overall value of the trade in each of these products appeared to be limited. In addition, in 1998 and 1999 there were two noncommercial exports of biological specimens to Russia and Germany (TRAFFIC Analysis of USFWS LEMIS data, 2001).

By contrast, the primary export in terms of both value and volume in 2000 appeared to be caviar. TRAFFIC based this conclusion on the price per unit of volume indicated in the export data. LEMIS records for 2000 showed at least 17 exports of eggs, presumably caviar, to Japan, Germany, Canada, and Uruguay. These

Box 6 TRAFFIC Analysis of LEMIS Data

Much of the information in this report regarding U.S. exports of sturgeon and paddlefish products was derived from TRAFFIC's analysis of data in USFWS' Law Enforcement Management Information System (LEMIS), a database that records USFWS import and export data. All wildlife (with a small number of exceptions) imported to or exported from the United States must be declared on a Fish and Wildlife Declaration form. The data contained on this form are compiled in LEMIS, which is separate from trade data compiled by other agencies such as the U.S. Customs Service. LEMIS data are generally recorded at the species level, including all CITES-listed species and many non-CITES species as well.

In some instances, the data reported in LEMIS on U.S. imports and exports of native Acipenseriformes and their products proved hard to interpret. TRAFFIC found, for example, that with very few exceptions LEMIS records the export of both caviar and live eggs under the generic wildlife description (the product in trade) of "eggs." Thus, it was hard at a glance to differentiate between exports of caviar and exports of live eggs destined for research or aquaculture programs in other countries, and required an examination of the declared value and unit of measure of each export and, in some instances, an analysis of the value per unit-of-volume of each export in order to categorize the shipments.

TRAFFIC further found that the unit of volume recorded for many exports was "NO" (i.e., number), without distinguishing whether that reflected, for example, the number of eggs, number of live fry, or number of containers of unspecified volume being exported. Specific cases in which the unit of volume recorded in the database precluded a determination about the nature of the export are noted in the text of this section.

There were also instances where exports of U.S. sturgeon or paddlefish appeared to have been mistakenly recorded as imports (e.g., where an "import" indicated that the country of origin of the wildlife was the United States, and the country of "export" had received no prior shipments of U.S. acipenseriform products and was not believed to have any aquaculture of the species in question). TRAFFIC examined these shipments and reclassified some on a case-by-case basis.

Overall, the LEMIS system proved very helpful in providing data critical for this report. Suggestions on how the system might be improved to make it more user-friendly and how its ability may be enhanced to provide more precise information are included in the recommendations in Section VII.

Source: TRAFFIC analysis of USFWS LEMIS data, 2002.

shipments totaled approximately 3,310 kg (7,328 pounds; 3.31 metric tons), and were valued at slightly over US$1 million, with more than 97 percent of the export volume destined for Japan. Based upon the valuation of the exports, prices for caviar exported to Japan ranged from US$180 to US$360 per kg (US$81 to US$162 per pound), with a median price for all of the exports of US$309 per kg (US$139 per pound) (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

Exports to other countries in 2000 that were identified by TRAFFIC as caviar appeared to be valued much lower. An export to Canada was valued at US$122 per kg (US$55 per pound), an export to Germany was valued at US$160 per kg (US$72 per pound), and an export to Uruguay was valued at US$154 per kg (US$69 per pound). One other export of eggs to Germany was also presumably caviar, but there was not enough information in the LEMIS data to determine a valuation. Additionally, two small shipments of caviar to Japan and Uruguay were recorded as having been seized (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

Although caviar appeared to replace live products as the major paddlefish export in 2000, data indicated that shipments of live products continued, destined for China, Romania, Germany, Bulgaria, and Israel. Export records showed at least seven

shipments identified as “eggs” that were determined by TRAFFIC to be live eggs based on their valuation. These exports totaled 251,500 unspecified numerical units, with an aggregate value of US$31,150, far below any rational market value for caviar. Furthermore, whereas all of the exports identified by TRAFFIC as being caviar originated from wild sources, all of the live exports were reported to originate from first-generation farmed sources. As of 2000, it was not believed that U.S. commercial aquaculture operations involving paddlefish had developed to a point where significant volumes of processed caviar were being produced. TRAFFIC was unable to determine the precise nature of one export of 15 kg of “eggs” to Japan, valued at US$100 (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

Partial export records from 2001 suggest that the external market for caviar from paddlefish roe expanded to more countries, although not all data for that year were available at the time of this report. Exports identified by TRAFFIC as caviar numbered at least 19, with five others identified as almost certainly being caviar, based upon the reported quantity and value, as well as the exporting and importing companies. The first 19 exports identified as caviar totaled approximately 767 kg (1,687 pounds), and had a reported aggregate value of US$279,651. The second five exports that TRAFFIC identified as caviar had an aggregate value of $15,326; however, the fact that the reported units were unspecified in the data precluded TRAFFIC from determining a price by kilogram or pound (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002). Whether the overall export market for paddlefish roe increased in 2001 could not be determined given the lack of complete data for the year; however, TRAFFIC would note that the United States indicated an expected export level of 7.7 metric tons of paddlefish caviar from wild sources, and 0.25 metric tons from captive propagation, to the CITES Secretariat in response to Notification 2001/005. Table 5.3.3 summarizes recorded legal U.S. exports of paddlefish products from the United States in 2000 and 2001; records for 2001 are partial.

In addition to the shift to caviar as the predominant export product in 2000 and 2001, three other possible trends also emerged from the data available for 2001. First, according to these data, TRAFFIC concluded that there were more destination markets reported for paddlefish caviar in 2001 than had been evident in 2000. While Japan remained the most significant importer, records also showed exports to Turkey, Greece, Chile, South Africa, Great Britain, Belgium, France, Spain, Italy, Singapore, and the United Arab Emirates.

Second, export records indicated that many of the importing parties appeared to be cruise lines, suggesting that importing destinations were likely points of embarkation or ports of call for cruise ships. Whether such trade continues to be a significant emerging market for American paddlefish caviar remains to be determined, pending the availability of further export data (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

Third, the price of paddlefish roe increased in some export markets in 2001 compared with 2000. Although some reported exports were valued at as little as US$233 per kg (US$105 per pound), others, particularly to Japan, were valued much higher. The average reported value of eight exports to Japan in 2001, which totaled 585 kg (1,287 pounds), was US$526 per kg (US$237 per pound). Values of individual shipments ranged from as low as US$265 per kg (US$119 per pound), to as high as US$905 per kg (US$407 per pound). Further data from 2001 and 2002 will be needed to determine whether a trend of increasing prices becomes evident in other markets. However, TRAFFIC noted that the value of individual exports varied widely within the same time period. Exports to some markets were valued significantly higher than concurrent exports to other markets, suggesting that the price of paddlefish caviar was determined more by what the market would bear in importing countries than it was by a steady increase in prices over time (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

Exports of products other than caviar also continued in 2001, although the partial nature of the data available for that year precluded TRAFFIC from determining its full volume. Reported exports included a small quantity of meat to Ukraine, as well as exports of product identified as “eggs” or “live” product to China.

Table 5.3.3 Legal Exports of Paddlefish Products from the United States, 2000–2001 (partial)*

Year	Number of Exports	Product	Total Quantity	Unit	Value (US$)	Source	Destination	Purpose
2000	14	Caviar	3,151	kg	974,903	W	Japan	T
	1	Eggs	15	kg	100	W	Japan	T
	1	Caviar	46	NO	5,324	W	Germany	T
	1	Caviar	2,350	gm	376	W	Germany	T
	1	Caviar	114,600	gm	17,620	W	Uruguay	T
	1	Caviar	63	kg	7,700	W	Canada	T
	3	Live Eggs	156,500	NO	15,950	F	China	T
	1	Live Eggs	50,000	NO	8,000	F	Romania	T
	1	Live Eggs	25,000	NO	4,000	F	Germany	T
	1	Live Eggs	10,000	NO	1,600	F	Bulgaria	T
	1	Live Eggs	10,000	NO	1,600	F	Israel	T
2001	8	Caviar	585	kg	236,075	W	Japan	T
	2	Caviar	29	kg	6,984	W	Turkey	T
	1	Caviar	24	NO	2,328	W	Greece	T
	1	Caviar	5	kg	1,920	W	Unspecified	T
	1	Caviar	19,056	gm	4,586	W	Chile	T
	1	Caviar	9,504	gm	2,328	W	South Africa	T
	1	Caviar	4,752	gm	1,154	W	Great Britain	T
	1	Caviar	24	NO	2,328	W	Belgium	T
	1	Caviar	60	NO	5,820	W	Spain	T
	1	Caviar	34	NO	3,298	W	Italy	T
	1	Caviar	19	kg	4,656	W	Italy	T
	1	Caviar	23,814	gm	5,280	W	Italy	T
	1	Caviar	10	kg	2,328	W	UAE	T
	1	Caviar	4,764	gm	1,164	W	UAE	T
	1	Caviar	57	kg	13,176	W	Singapore	T
	1	Caviar	16	NO	1,552	W	France	T
	1	Meat	60	kg	95	W	Ukraine	T
	3	Live Eggs	524,500	NO	32,690	F	China	T
	1	Live	56,000	NO	5,600	C	China	T

Key: NO = Number—could indicate number of eggs or other; W = wild; F = first generation; C = captive-bred; T = commercial trade.

* Source: TRAFFIC analysis of USFWS LEMIS data, February 19, 2002.

These latter exports to China totaled 580,500 unspecified units. TRAFFIC was unable to determine with precision how many of these exports may have comprised fertilized eggs, live fry, or possibly a combination of both (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

TRAFFIC noticed one peculiarity in the USFWS export data for 2001 that were shown in Table 5.3.3. In late 2000, the European Union (EU) temporarily suspended all imports of paddlefish products from the United States, yet exports of paddlefish products to EU countries were recorded by USFWS as having occurred during the term of the suspension. The EU import suspension followed the 2000 Significant Trade Review on paddlefish, and a subsequent finding from the EU's Scientific Review Group (SRG) that there was not enough information on which to base non-detriment findings. As noted in Section IV, commercial catch of paddlefish in the United States is regulated by state rather than by federal authorities. Individual states decide whether commercial catch will be permitted, whether there will be quotas or other restrictions, and how fishermen are required to report their catch. Specific reasons for the import suspension included the lack of a national quota on catch, inconsistencies in state laws and regulations regarding legal catch and trade of paddlefish, and concern that some

states have not monitored catch levels carefully. The EU import suspension, which did not affect the legal international trade of other North American acipenseriform species or exports of paddlefish to non-EU countries, was lifted on July 18, 2001 (SRG 2001). Exports identified by TRAFFIC as paddlefish caviar, based on their relative volume and value, were recorded to Great Britain in May 2001, to Italy in both May and June 2001, and to Greece in April 2001, all before the import suspension ended. TRAFFIC was unable to determine whether these exports indicate a problem with enforcement, or whether exceptions were made to allow the shipments to enter the EU (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

Finally, TRAFFIC noted that some of the nations shown in export records as destinations for U.S. paddlefish products between 1995 and 2001 have established quotas for the export of paddlefish products. In 2001, the Czech Republic, Hungary, and Russia submitted export quotas for fingerlings, live fish, or fertilized eggs from aquaculture operations. The Czech Republic submitted an export quota of 100,000 fingerlings from aquaculture, Hungary submitted an export quota of 1,000 live fish from aquaculture, and Russia submitted a quota of 5 kg of fertilized live eggs from Armenian aquaculture, to be re-exported from the Russian Federation. Russia also submitted an export quota for 5 kg of live eggs in 2000. This may indicate that some of the exports of American paddlefish eggs and fingerlings documented above over the years have been used to establish aquaculture operations that are now capable of supplying eggs and fry for the export market (CITES 2001g).

CITES permits. The USFWS process to obtain a CITES permit to export paddlefish products of wild origin, including findings of non-detriment and legal acquisition, involves the provision and review of information on several aspects of the catch, and the fishermen and wholesalers/brokers involved. When applying for a CITES export permit, USFWS requires the following to determine legal acquisition: (1) documents to show legal possession of the roe from the time it is harvested until final ownership by the applicant (i.e., documentation of legal catch by fishermen, bill of sale to broker/wholesaler, bill of sale from broker to exporter); (2) a copy of a valid commercial fishing license (in states where applicable, also a copy of a valid paddlefish permit); (3) the date and location of the catch (e.g., boat ramp, or nearest town, or river mile marker); and (4) the type of gear used. When an application is received, USFWS/DMA contacts the appropriate state agency to ensure that all catch was conducted in compliance with state regulations (Charles Hamilton, USFWS, *in litt*. to Andrea Gaski, USFWS, August 30, 2000).

The CITES permit process is a source of significant contention. Fishermen and wholesalers have noted to TRAFFIC that the process can be lengthy—sometimes taking months—which they noted can make it difficult for exporters who are dealing with a perishable product to effectively engage in international trade. In interviews and conversations with TRAFFIC, numerous individuals who have sought export permits from USFWS protested that the amount of time and paperwork involved before a permit is granted or denied posed a significant obstacle to developing an export market for U.S. paddlefish products (TRAFFIC interviews with commercial fishermen and wholesalers, 2001).

However, USFWS notes that the reason the process becomes lengthy in most cases is because the applicant has been unable to supply adequate documentation for USFWS to make a finding of legal acquisition and/or non-detriment. USFWS frequently must undertake numerous communications with the applicant, requesting documentation that was not submitted with the application (Marie Maltese, USFWS, *in litt*. to TRAFFIC North America, January 2002).

Furthermore, as was shown in Section IV, paddlefish catch is regulated by the states, with widely varying requirements regarding catch reporting, gear restrictions, open and closed waters, etc. Rules can vary even within river systems. Therefore, findings of legal acquisition and non-detriment require that USFWS coordinate with the states to do a thorough job of investigating the origin and chain of custody of the paddlefish involved on an individual basis. TRAFFIC concluded after reviewing several CITES permit applications for paddlefish roe that each one tells its own

story. It is impossible to generalize about whether delays in the process should be primarily attributed to the bureaucratic process, to the failure of commercial interests to fully understand and readily comply with permit requirements, or simply to the fact that issuing CITES permits promptly can be difficult when there are so many factors and disparate state regulatory regimes involved.

The permit process has in some cases been made somewhat easier. For example, in April 2000, USFWS/OSA (now USFWS/DSA) issued a memorandum to USFWS/OMA (now USFWS/DMA), providing general advice for the export of paddlefish roe obtained from the Glendive Paddlefish Caviar Project in Montana and Gold Star Caviar in North Dakota. The memorandum indicated a non-detriment finding for the cooperative sustainable paddlefish sport fishery in those states as it is managed under the MOUs between the Glendive Chamber of Commerce and the Montana Department of Fish, Wildlife and Parks and between the Williston Area Chamber of Commerce and the North Dakota Game and Fish Department. Essentially, as long as the states and their private partners maintain the terms of their respective MOUs, USFWS is inclined to make a finding of non-detriment. Rather than having to investigate every sale individually, this mechanism provides a way to speed up the application process, without compromising the conservation of the species (Susan Lieberman, Chief, USFWS/OSA, *in litt*. to Chief, USFWS/OMA, April 4, 2000).

Shovelnose Sturgeon

Shovelnose sturgeon are endemic to the United States, which is the only source of this species in trade. Tracking down trade statistics for the shovelnose sturgeon has proven difficult, for reasons detailed below.

Domestic trade. Shovelnose sturgeon caviar is produced in a fashion similar to that of paddlefish caviar in several U.S. states, but usually in far smaller quantities. Unfortunately, states have not traditionally regulated shovelnose sturgeon catch (commercial or sport) as closely as they regulate paddlefish catch. That makes it difficult to obtain an accurate picture of the scope of the domestic market and trade during recent years, and has also complicated the work of USFWS CITES permitting authorities when making findings of non-detriment and legal acquisition.

Shovelnose sturgeon caviar is being sold by small retailers in states such as Tennessee, Kentucky, and Illinois. However, from the available information, it is impossible to track the total amount of caviar being produced, or where it is being marketed and sold domestically. In the spring of 2001, fishermen appeared to be receiving US$40–50 per pound for shovelnose sturgeon roe, with the caviar retailing for around US$10 per ounce. Shovelnose meat can be smoked and sold, but most consumption appears to be local (TRAFFIC interviews with Tennessee fishermen/wholesalers, 2001). As with paddlefish, a 2002 TRAFFIC review of commercial Internet sites advertising shovelnose sturgeon (also marketed as "hackleback") roe found prices in the range of US$9.95 to US $12 per ounce (US$159.20–US$192 per pound; US$ 350.25–US$422.40 per kg).[9]

Export markets. It is believed that the species has not traditionally played a significant role in international trade. Prior to 1998, there are no data available on exports of shovelnose sturgeon roe or meat. There was a record of one 1996 shipment, involving 10 items of live wild-caught specimens valued at US$10, to the Solomon Islands. A 1997 transaction involved 80 live, wild-caught specimens, valued at US$200, shipped to Japan (pers. comm., Craig Hoover, TRAFFIC North America, 2001).

A review of USFWS LEMIS records from 1998 to 2001 revealed only four exports involving shovelnose sturgeon. These included two shipments of specimens for scientific research in 1998 (three specimens to Russia and six to Germany), one shipment of three scientific specimens to Germany in 1999, and a single export of an unspecified amount of caviar, valued at US$185, to the Philippines in

[9] Web sites reviewed for shovelnose sturgeon roe were the same as those reviewed for paddlefish; the specific Web sites reviewed are not included here. Readers interested in the subject can review which retailers are selling shovelnose sturgeon roe, and current prices, through a Web search using the key words "caviar" and "paddlefish" or "hackleback."

1999, likely to a cruise ship (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002). The isolated nature of these exports precludes an attempt to identify any substantive patterns in the export trade.

The lack of export records may be attributable to the fact that the shovelnose sturgeon was not covered under CITES until the 1998 decision to list all acipenseriform species in Appendix II. Because fish for human or animal consumption that is not CITES-listed does not have to be declared to USFWS, it is possible there was some pre-1998 trade for which there are no data (pers. comm., C. Hoover, TRAFFIC North America, 2001). As discussed in Sections III and IV above, it is also worth noting that most commercial fishermen traditionally regarded shovelnose sturgeon as a "trash" fish, yielding such a small amount of roe that it was considered not really worth targeting when a fishing effort focused on paddlefish would likely prove far more profitable.

The submission of CITES permit applications in 2000 and 2001 for shovelnose sturgeon roe suggests that caviar dealers may have begun to seek export markets for shovelnose sturgeon caviar. A review of several CITES permit applications from 2000 and 2001, obtained under the Freedom of Information Act, showed that USFWS received export applications for shovelnose sturgeon roe, yet LEMIS data obtained in 2002 included only the one very small export from 1999 mentioned above.

While the volumes of shovelnose sturgeon roe being harvested and processed for caviar appear to remain only a fraction of those for paddlefish, prices for North American roe may be rising enough that even small volumes are now worth the effort to process and sell, sometimes in conjunction with larger volumes of paddlefish roe. The possible emergence of such a market has generated concern among conservationists and federal and state authorities regarding the adequacy of current management regimes in many states to ensure that shovelnose sturgeon catch remains within sustainable levels.

An example of this came in a January 2000 application to export an undetermined amount of shovelnose sturgeon roe, some of it reported as being taken in Illinois waters of the Wabash River. USFWS discussions with biologists from the state of Illinois indicated that shovelnose sturgeon populations were considered fairly healthy, and that there was an open fishery in the Wabash River, with no catch limits for the species. However, USFWS noted that there was also no specific information regarding the species' abundance in the river, which had not been considered a problem because there were no indications of a market for shovelnose sturgeon roe before 1999. In that year, according to USFWS, total harvest of roe reported to the state exceeded 4,000 pounds[10] (2,500 pounds by one commercial party) in the Wabash River alone. State biologists were unable to determine whether or not the catch level needed to produce this volume of roe was detrimental because of a lack of population studies on shovelnose sturgeon (USFWS CITES Permit Application no. 18899).

USFWS made some calculations, noting the small size of the species, the limited amount of roe that can be harvested from a single female (less than 1 pound; on average 0.5 pound), and a sex ratio for the species of four males for each female. Because the sexes are morphometrically similar, it is impossible to tell them apart visually. By those calculations, USFWS estimated that more than 8,000 mature fish may have been caught to produce the amount of roe reported by the applicant (not including juveniles possibly taken as bycatch). Although USFWS made a finding of non-detriment, based upon the lack of substantial information from state authorities indicating that the export of this shovelnose roe would be detrimental, it expressed strong concerns about whether the number of shovelnose sturgeon derived from the fishery would be sustainable if catch levels remained unchecked (USFWS CITES Permit Application no. 18899).

TRAFFIC remains concerned that few studies have been done to document shovelnose sturgeon abundance in states and rivers throughout their range, and whether the species can withstand the increasing levels of catch and trade that seem to be occurring in several

[10] The state reported a harvest of 3,529 pounds of roe for the CITES Significant Trade Review.

fisheries. It may be that the species is abundant, but the history of sturgeon and paddlefish fisheries generally in North America would suggest caution.

Fortunately, enough concern has been raised about shovelnose sturgeon catch, partly because of the application previously discussed, that many of the states that allow commercial fishing are beginning to look into the status of the fish and tightening catch regulations. However, according to USFWS, during the 2001 catch season there was very little shovelnose sturgeon roe on export applications; it would appear that most fishers are continuing to rely on the larger yields from paddlefish (Marie Maltese, USFWS/DMA, *in litt*. to TRAFFIC North America, January 2002).

Pallid Sturgeon

There is no legal commercial trade of the pallid sturgeon, which is designated as endangered under the ESA in 1990. Catch is prohibited. Records show only three exports of pallid sturgeon between 1998 and 2001, with all of these occurring in 1998. These exports included nine specimens exported to Germany, and three specimens exported to Russia, all for purposes of scientific research (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

Alabama Sturgeon

There is no legal commercial trade of the Alabama sturgeon, which was designated as an endangered species under the ESA in 2000. Catch is prohibited. There are no records of exports for scientific research purposes between 1998 and 2001 (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

Lake Sturgeon

Some Canadian provinces permit commercial and sport catch of native stocks of lake sturgeon, subject to catch quotas, creel limits in sport fisheries, and other applicable regulations. No U.S. states allow commercial catch, and those that allow sport catch regulate the practice. Therefore, Canada is the only source of commercially caught lake sturgeon in trade; U.S. commercial trade in the species originates from the Canadian fisheries.

Canada

Canada's commercial lake sturgeon industry is currently centered in the fisheries of Quebec and Ontario. As was shown in Section IV above, Quebec reported catch of approximately 460,000 pounds (208,714 kg; ~208.7 metric tons) of lake sturgeon in both 1997 and 1998, and 394,695 pounds (177,613 kg; ~177.6 metric tons) in 1999 (P. Hall, DFO, *in litt*. to TRAFFIC North America, September 28, 2001). Ontario produced only 10,000–15,000 pounds (5,000–7,000 kg; 5–7 metric tons) of lake sturgeon annually during the late 1990s (Al Murray, MNR Lake Erie Management Unit, *in litt*. to Robert Jones, DFO, August 30, 2000).

Domestic trade. Similar to the case with Atlantic sturgeon, a comparison of catch data with reported exports suggests a domestic market in Canada for lake sturgeon products. For example, in 1998, lake sturgeon fisheries in Ontario and Quebec reported a cumulative catch of 473,560 pounds (213,102 kg; ~213.1 metric tons) of fish. Canada reported the export of 86,265 pounds (39,034 kg; ~39 metric tons) of commercial lake sturgeon exports, presumably meat, in 1998. In 1999, exports rose to 131,191 pounds (59,363 kg; ~59.4 metric tons), while catch in Quebec alone was reported as 408,441 pounds (185,655 kg; ~185.7 metric tons) (Al Murray, MNR Lake Erie Management Unit, *in litt*. to Robert Jones, DFO, August 30, 2000; P. Hall, DFO, *in litt*. to TRAFFIC North America, September 28, 2001). Even after accounting for the difference between reported catch (whole fish) and exports (meat), these figures suggest that a there is a likely domestic market for lake sturgeon, primarily meat, although TRAFFIC was unable to determine its precise extent.

Prices for lake sturgeon reportedly varied among water bodies. For example, in Ontario in 1998, lake sturgeon caught in Lake Huron were reported to bring $2.65 per pound, whereas lake sturgeon taken from Rainy Lake brought $1.75 per pound. The average price among the six water bodies recorded (Lake Huron, Lake Nipigon, Lake St. Clair, Namakan

Lake, Rainy Lake, and the Seine River) was about $2 per pound. In 1999, prices for these six water bodies varied from $1.79 per pound to $2.75 per pound. Because Lake Huron produced approximately 75 percent of the lake sturgeon caught in each of these years, most of the product reaching the market attracted the higher prices (Al Murray, MNR Lake Erie Management Unit, *in litt*. to Robert Jones, DFO, August 30, 2000).

Export markets. Pursuant to Decision 11.58, in January 2001, Canada reported to the CITES Secretariat that although Canada does not normally use export quotas for sturgeon products, figures of 170,000 kg (374,000 pounds; 170 metric tons) of meat and 500 kg (1,100 pounds; 0.5 metric tons) of caviar could be used as such by CITES (L. Maltby, Director, Species at Risk Branch, CWS, *in litt*. to Willem Wijnstekers, Secretary General, CITES Secretariat, January 25, 2001). The 170,000 kg of meat indicated as an export quota parallels the combined catch quotas for Ontario and Quebec in 2000; actual exports in recent years have been much lower. Table 5.3.4 summarizes reported lake sturgeon exports from Canada during the years 1998 to 2000. Because the lake sturgeon was not listed in CITES Appendix II until 1998, exports for prior years were not recorded in CITES trade data.

Based upon an analysis of available Canadian fisheries and export data, and import data from the United States—a large importer of Canadian lake sturgeon exports—the most significant export market appears to be for lake sturgeon meat. Between 1998 and 2000, the United States reported 23 imports of Canadian lake sturgeon meat. Nineteen of these imports, totaling 60,615 kg (133,353 pounds; ~60.6 metric tons), were valued at US$470,243 (an average of US$3.53 per pound). Four other exports of an unspecified volume of 3,175 units were valued at US$72,807.

One market for Canadian lake sturgeon meat is New York state. Oddly, responding to the 2000 CITES Significant Trade Review, New York reported importing approximately 150,000 pounds (~68,000 kg) in 1999, which is significantly more than was indicated in USFWS records for the entire United States. Canadian lake sturgeon meat, principally from Quebec's St. Lawrence fishery, supports an active sturgeon processing smoke house industry and market in the New York City area (Patrick Festa, Inland Fisheries Management Section, New York State Department of Environmental Conservation, *in litt*. to Teiko Saito USFWS/OMA, August 22, 2000).

Table 5.3.5 summarizes U.S. imports of lake sturgeon meat and other products from Canada during the years 1998 to 2000. Data for the year 2001 were incomplete at the time of this report.

In its 2001 letter to the CITES Secretariat in response to Notification 2001/005, CWS also

Table 5.3.4 Canadian Lake Sturgeon Commercial Export Summary, 1998–2000 (Product from Wild Sturgeon Only)*

Year	Province	Number of Commercial Export	Cumulative Weight of Commercial Export	Provincial Catch Quota and/or TAC*	Comments
1998	Ontario	2	2,706 lb (1,224.4 kg)	25,417 lb (11,438 kg)	Total catch 14,696 lb (6,613 kg)
	Quebec	10	83,559 lb (37,810 kg)	No TAC set	Total catch 458,864 lb (206,489 kg)
1999	Ontario	4	6,777 lb (3,067 kg)	25,417 lb (11,438 kg)	Total catch 13,746 lb (6,248 kg)
	Quebec	13	124,414 lb (56,296 kg)	441,000 lb quota; TAC 30,433 fish	Total catch 394,695 lb (177,613 kg)
2000	Ontario	2	7,268 lb (3,289 kg)	25,417 lb (11,438 kg)	N/A
	Quebec	21	133,667 lb (60,483 kg)	352,800 lb quota; TAC 24,345 fish	

Key: TAC = Total Allowable Catch; N/A = Not available.

* Source: Al Murray, MNR Lake Erie Management Unit, *in litt.* to Robert Jones, DFO, August 30, 2000; P. Hall, DFO, *in litt.* to TRAFFIC North America, September 28, 2001.

Table 5.3.5 U.S. Imports of Canadian Lake Sturgeon Products, 1998–2001 (partial)*

Year	Number of Imports	Product	Total Quantity	Unit	Value (US$)	Source	Purpose
1998	5	Meat	18,170	kg	132,681	W	T
1999	6+	Meat	28,392	kg	197,477	W	T
	2	Meat	271	NO	27,020	W	T
	2	Trophy	2	NO	0	W	N
	1	Live	250,000	NO	2,500	W	T
2000	8	Meat	14,053	kg	140,085	W	T
	2	Meat	2,904	NO	45,787	W	T
	3	Spec.	31	NO	0	W	N

+ U.S. import data also record one seizure of 1,163 kg of meat, valued at $8,847, from an unspecified source in Canada.

Key: NO = Unit Unspecified—could indicate numerical unit or other; W = wild; T = commercial trade; N = Noncommercial; Spec. = specimens.

* Source: TRAFFIC analysis of USFWS LEMIS data.

indicated the possible export of 500 kg (1,100 pounds) of caviar (L. Maltby, Director, Species at Risk Branch, CWS, *in litt*. to W. Wijnstekers, Secretary General, CITES Secretariat, January 25, 2001). This does not mean that the Canadian government expects a significant export market in the near future. Historically, lake sturgeon caviar commanded a high price during the early years of the fisheries in the nineteenth century; however, comparative information on recent prices or exports is lacking.

Finally, Canada reported to the CITES Secretariat the possible export of 1,000 kg of live animals in 2001, but noted that exports of live lake sturgeon originate in aquaculture facilities, and therefore are exempt from Decision 11.58 (L. Maltby, Director, Species at Risk Branch, CWS, *in litt*. to W. Wijnstekers, Secretary General, CITES Secretariat, January 25, 2001).

Actual exports of live lake sturgeon products during the period 1997 to 2000 appeared to be much lower than the 1,000 kg reported as possible for 2001. A total of four CITES permits were issued in 1999 and 2000, of which three were used. Exports included live fry and fertilized eggs to the United States for purposes of propagation or reintroduction into the wild. These were recorded as noncommercial, scientific exports. Because they were recorded by numerical unit (i.e., number of eggs or fry) rather than by weight, it was not possible to determine how they might compare to possible export levels reported for 2001. Table 5.3.6 summarizes Canadian scientific lake sturgeon exports between 1997 and 2000.

The United States

There is no legal commercial trade of lake sturgeon from U.S. populations. Michigan, Minnesota, and Wisconsin are the only U.S. states with significant lake sturgeon sport fisheries, but not all of these states permit trade of fish taken by sport anglers. In addition, the number of lake sturgeon caught in states that allow the sale of sport-caught fish are too small to sustain a commercial industry. Therefore, it is believed that the overwhelming bulk of lake sturgeon and lake sturgeon products in trade in the United States originated in Canadian fisheries.

Domestic trade. Because lake sturgeon are classified as threatened or endangered by many states within the species' historic range, the legal trade in lake sturgeon or their products is more restricted than that of other North American Acipenseriformes such as the paddlefish, shovelnose sturgeon, and white sturgeon. In fact, of 10 U.S. states polled in a 1998 survey, just four reported allowing trade in lake sturgeon flesh and caviar, and only three permitted trade in live lake sturgeon as ornamental fish—in the aquarium industry or

otherwise (Bruch, 1999). Table 5.3.7 shows the results of the poll among participating U.S. states.

Among states with lake sturgeon sport fisheries in 2000, Michigan reported a likely market for smoked sturgeon and caviar within the state, but had no data on its size. The state also reported no knowledge of anyone selling lake sturgeon or products imported from out of state (Gary Whelan, Fish Production Manager, Michigan Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 29, 2000). Minnesota trade in lake sturgeon is believed to have diminished in recent years because of lack of viable eggs available from commercial sources. There is a potential that licensed aquatic farms may be able to produce a viable egg source in the future, but at present local consumption is based on sport catch where the fishing season is open, and includes tributaries of the upper St. Croix and the Rainy rivers (L. Erickson-Eastwood, Fisheries Program Manager, Minnesota Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 23, 2000). Wisconsin does not allow legal trade of lake sturgeon flesh or caviar (Bruch 1999).

As noted previously, the state of New York has been a major market for imported Canadian lake sturgeon meat. The lake sturgeon is classified as a threatened species in New York; to import or process lake sturgeon requires a

Table 5.3.6 Canadian Scientific Exports of Lake Sturgeon (Hatchery-Reared Live Fish), 1997–2000*

	Total CITES Export Permits Issued	Commercial Export of Product	Scientific Research Export of Live Animals	Live Animal Exports/ Purpose Omitted	Comments
1997	0	0	0	0	Species not CITES-listed in 1997; no exports recorded.
1998	0	0	0	0	No live exports recorded in 1998.
1999	2	0	2	0	1 export of 50,000 captive-propagated Ontario fry to the U.S. for introduction to the wild; 1 export of 50,000 fertilized eggs, captive-propagated from Ontario to U.S. for introduction to the wild.
2000	2	0	2	0	1 export of 40,000 live fry from Ontario, captive-bred, exported to U.S. for propagation and re-introduction; 1 permit issued but not used for 20,000 live eggs.

* Source: P. Hall, DFO, *in litt.* to TRAFFIC North America, September 28 and November 8, 2001.

Table 5.3.7 Legal Trade of Lake Sturgeon in the United States*

State	Permits Legal Trade of Flesh and Caviar	Permits Legal Trade in Live Lake Sturgeon
Illinois	No	No
Indiana	No	No
Iowa	No	No
Michigan	Yes	Yes
Minnesota	Yes	Yes
Missouri	No	No
New York	Yes	Yes
Ohio	Yes	No
Tennessee	No	No
Wisconsin	No	No

* Source: Bruch (1999).

license. An Importer License, which costs $150, allows the holder to import legally taken lake sturgeon into New York, subject to certain requirements specified in New York law under "Special Rules: lake sturgeon (*Acipenser fulvescens*)." These include the following: (1) the importer must have a certificate of inspection from the source jurisdiction attesting to the fact that the fish were taken legally; (2) each lake sturgeon must have a valid tag attached; (3) the fish must be packed in sealed containers, with valid labels; and (4) the importer must keep specific records for two years on each shipment. A Processor License is required for those who process legally imported lake sturgeon in New York State. Processors must also meet a number of specific requirements to obtain and keep their licenses, including maintaining records on each lake sturgeon shipment (6 NYCRR, Part 182.7).

Export markets. In recent years, the United States has reported a small number of exports of lake sturgeon or products derived from the species. In 1998, the United States exported 1,120 live fish to Taiwan (560 from the wild and 560 from a captive breeding source), as well as scientific specimens to Germany (6) and Russia (3). There was also one 1998 record of an export to Russia of 279 kg of lake sturgeon meat, valued at US$6,300, which originated in Canada. In 1999 there was a single record of an export of three scientific specimens to Germany. There were no records of lake sturgeon exports from the United States in 2000, and data from 2001 were partial (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

White Sturgeon

The only source of commercial trade in white sturgeon is the United States. Canada allows no commercial trade in white sturgeon products from domestic sources. In the United States, use and trade of white sturgeon currently centers on fresh or processed meat and caviar for U.S. sale or export.

Canada

In 1994, British Columbia closed the Fraser River fishery and banned the possession or retention of indigenous white sturgeon in the province (RL&L Environmental Services 2000a). One exception regards live eggs and fry of the endangered population of Kootenai River white sturgeon, which are imported and exported by Canada as part of hatchery-based recovery efforts. In 2000, Canada reported the export of two shipments of live product to the United States, consisting of 1,500 live yearlings and 50,000 live larvae. The purpose of the exports was recorded as captive breeding (P. Hall, DFO, *in litt*. to Traffic International, November 2001).

Although British Columbia has banned possession or retention of native white sturgeon, the province allows the importation of white sturgeon products from the United States with proper CITES documentation. Canada, including British Columbia, has served as a significant market for commercial white sturgeon products from the United States, primarily meat, during some recent years. Prior to 1999, U.S. export records further indicate that Canada was a market for live white sturgeon for the aquarium or ornamental fish trade (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002). Such trade is documented in more detail below as part of the U.S. export market.

The United States

As was detailed in Section IV, most U.S. commercial fishing for white sturgeon occurs within the Columbia River system in Oregon and Washington. However, the vast majority of the Columbia River catch is allocated to sport fisheries (Beamesderfer 1999; DeVore et al. 1999; JCRMS 2001a). In addition, egg sales from lower Columbia River commercial and sport-caught sturgeon are currently prohibited (R. Beamesderfer, *in litt*. to TRAFFIC North America, September 2001). While California, Idaho, and Montana do not allow commercial catch of white sturgeon, another primary source of white sturgeon products in trade is commercial aquaculture, which to date has concentrated in California.

Domestic markets. Based upon the significant disparity between the amount of white sturgeon being caught from the wild or produced through aquaculture in the United States, and the fairly limited amounts of meat and caviar that have reportedly been exported in recent years, TRAFFIC has concluded that

for the most part, the market for these products is domestic. For example, regarding meat, in 1999 and 2000 the Columbia River commercial fishery reported the cumulative catch of 20,400 white sturgeon (JCRMS 2001a). An undetermined amount was also produced through commercial aquaculture in California. U.S. export records for these two years (shown below under export markets) reported the total export of only 3,792 kg (8,342 pounds) of white sturgeon from both wild and farmed sources. Furthermore, Beamesderfer (1999) estimated the value of the commercial catch of white sturgeon in the lower Columbia River alone at approximately $275,000 in 1997, when 12,800 fish were caught. By contrast, the combined value of exports for 1999 and 2000 from both wild and farmed sources was $32,630 (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002). These figures suggested to TRAFFIC that the bulk of the volume and value of the market for white sturgeon meat were found inside the United States.

Similarly, most caviar production from white sturgeon appeared to be consumed domestically. Because there is at present no legal trade in white sturgeon caviar from wild sturgeon in British Columbia, Washington, Oregon, or California, all legal caviar from the species can be presumed to originate from commercial aquaculture.

The largest commercial aquaculture operation producing white sturgeon products (caviar and meat) is Stolt Sea Farm (a component of a multinational corporation), based in Elverta, California. Stolt Sea Farm produces caviar under the Sterling label, and also sells whole white sturgeon averaging 16 pounds. As of the fall of 2001, roe products included Sterling Classic Caviar (US$30 per ounce), Sterling Premium Caviar (US$36 per ounce), Sterling Royal Black Caviar (US$45 per ounce), and Sterling Imperial Caviar (US$45 per ounce) (Stolt Sea Farm 2001a). Prices for at least some of these products rose in 2002, when Sterling Classic Caviar was being marketed for US$35 per ounce, and Sterling Premium Caviar was being marketed for US$42 per ounce; 2002 prices for the other two products, which were not in stock at the time of this report, were unavailable (Stolt Sea Farm 2002).

U.S. companies that rear white sturgeon commercially have been working to build both domestic and international markets for their white sturgeon products as alternatives to Caspian Sea caviar. White sturgeon caviar is touted as being similar to Caspian Sea varieties. For example, Stolt's Sterling Classic Caviar is marketed as "comparable to the best Osetra caviar," and Sterling Premium Caviar is said, by the company, to be "similar to premium Beluga" (Stolt Sea Farm 2001a). Because domestic trade is not regulated, it was not possible to determine the level of domestic demand for these products.

Export trade. Similar to paddlefish, the export market for white sturgeon products appears to have undergone important changes in recent years. Available data indicate that export markets for white sturgeon products within the past five years have included fry, fingerlings, and eggs for commercial aquaculture; live fish for the aquarium and ornamental trade or aquaculture; fresh or processed meat; and caviar. Table 5.3.8 summarizes U.S. export data for 1997 through 2001 (data for 2001 are partial).

As Table 5.3.8 indicates, little data are available regarding U.S. exports of meat or caviar from white sturgeon prior to 1998, the first year in which all sturgeon exports required a valid CITES permit. Several exports reported in 1996 involved live specimens, and a review of U.S. export data showed 15 exports of live sturgeon in 1997. Based upon an analysis of USFWS export data, 13 of these exports appeared to involve the sale of live specimens for the commercial aquarium or ornamental fish trade in Canada and Mexico. One export appeared to involve the sale of live eggs or fry to Taiwan, while another appeared to be the noncommercial transport of live fish to a public aquarium in Japan (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

During 1998 and 1999, the principal white sturgeon export product recorded was meat. However, because such shipments did not have to be reported prior to 1998, these exports may have represented the continuation of existing business relationships. Some trade in live fish, presumably for the aquarium or ornamental industry, also continued in 1998 with Canada and Mexico. During these years, USFWS

Table 5.3.8 U.S. Exports of White Sturgeon Products, 1997–2001 (partial)*

Year	Number of Exports	Product	Total Quantity	Unit	Value (US$)	Source	Destination	Purpose
1997	6	Live	253	NO	322	W	Canada	T
	1	Live	6	NO	0	C	Japan	N
	5	Live	300	NO	340	W	Mexico	T
	2	Live	125	NO	79	C	Mexico	T
	1	Live	3,000	NO	4,800	C	Taiwan	T
1998	10	Meat	526	kg	4,305	F	Canada	T
	1	Meat	90	kg	600	C	Canada	T
	1	Meat	90	kg	650	F	Taiwan	T
	6	Live	225	NO	381	W	Canada	T
	4	Live	115	NO	176	W	Mexico	T
	1	Eggs	1	kg	375	F	Sweden	T
	1	Eggs	2	kg	570	W	Germany	T
	1	Eggs	88	kg	7,774	C	Russia	T
	1	Spec.	6	NO	0	O	Germany	N
	1	Spec.	3	NO	0	O	Russia	N
	1	Unsp.	18	kg	0	F	Taiwan	?
1999	27	Meat	1,674	kg	15,752	F	Canada	T
	3	Meat	181	kg	1,766	C	Canada	T
	1	Meat	107	kg	1,034	F	Taiwan	T
	2	Meat	71	kg	460	W	Taiwan	T
	1	Meat	1,691	kg	13,048	W	Great Britain	T
	1	Eggs	23	kg	223	F	Canada	T
	4	Live Eggs	80,000	NO	0	W	Canada	N
	1	Spec.	3	NO	0	W	Germany	N
2000	1	Meat	68	kg	570	W	Canada	T
	2	Live Eggs	20,000	NO	0	W	Canada	N
2001	1	Meat	150	kg	1,480	F	France	T
	1	Eggs	199	kg	87,863	F	France	T
	1	Eggs	97	kg	34,004	F	France	T
	1	Eggs	1	NO	63	W	Canada	?
	1	Eggs	430	gm	126	F	Great Britain	T
	1	Eggs	3	kg	243	F	Japan	T
	1	Eggs	5	kg	3,925	F	Singapore	T
	1	Eggs	480	gm	227	F	Belgium	T
	5	Live Eggs	50,000	NO	0	W	Canada	N

Key: NO = Number—could indicate number of eggs or other; W = wild; F = first generation; C = captive-bred; T = commercial trade; N = Noncommercial; Spec. = specimens; Unsp. = Unspecified.

* Source: TRAFFIC analysis of USFWS LEMIS data.

export data show 44 exports of meat, from both wild and farmed sources, totaling 4,430 kg (9,746 pounds), with an aggregate value of $37,615. The primary consuming country was Canada, although meat was also exported to Great Britain and Taiwan. Reported values of exported meat shipments to various countries ranged from approximately US$6.50 to US$10 per kg (US$3 to $4.50 per pound). There were also three reported exports in 1998 of small amounts of what was presumably caviar, based on the recorded value, destined for Germany, Russia, and Sweden (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

After 1999, the export of live white sturgeon products was prohibited by the USFWS/DSA because of disease transmission concerns, which ended shipments for the aquarium or ornamental fish trade (Marie Maltese, USFWS, *in litt*. to TRAFFIC North America, January 2002). USFWS export data also showed very limited exports of meat and caviar in 2000 and 2001. LEMIS records reviewed in early 2002 showed only one reported export of white sturgeon meat to Canada in 2000; in fact, that was the only commercial export of any white sturgeon product recorded for that year. Partial data from 2001 also showed only one meat export, to France, and six exports of eggs, five of which were identified by TRAFFIC as caviar based upon their value by volume. Importing countries included France, Great Britain, Belgium, and Singapore (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002).

Stolt Sea Farm, which has been the largest exporter of white sturgeon products, explained the lack of exports in 2000 and 2001. According to the company, USFWS stopped granting export permits in 2001 after the agency raised questions about the source of the company's broodstock. Although the issue has since been resolved, the company believes that it may take some time to rebuild the customer base (pers. comm., P. Struffenegger, Stolt Sea Farm, 2002).

In addition to commercial exports, the United States exported significant numbers of live white sturgeon eggs to Canada between 1999 and 2001 as part of recovery efforts for the Kootenai River white sturgeon population. These noncommercial shipments included 80,000 eggs in 1999, 20,000 eggs in 2000, and 50,000 eggs in 2001 (TRAFFIC analysis of USFWS LEMIS data, February 19, 2002). As was discussed in Section 3.9 of this report, the United States and Canada have engaged in cooperative efforts to recover the Kootenai River white sturgeon population since its listing as an endangered species under the ESA in 1999. As part of the recovery effort, the Kootenai Tribe of Idaho has transferred live eggs to the British Columbia Ministry of Environment (BCME), and beginning in 2000, BCME began to transfer live larvae or yearling fish back to the United States. These shipments fall outside of the USFWS prohibition of commercial trade of live white sturgeon.

Finally, LEMIS records indicate that the United States has imported, as well as exported, white sturgeon products in recent years. For example, in 1998, the United States reported four shipments of white sturgeon meat from Great Britain, originating from the wild, to a hotel in Las Vegas. Interestingly, the British Company involved was the same one that had earlier received a much larger shipment of white sturgeon meat, also originating from wild sources, from the United States. TRAFFIC speculates that this was a re-import of sturgeon meat that was smoked in Great Britain and then resold to the U.S. hotel. LEMIS data also recorded a small shipment of eggs, likely caviar, from a ranched source in Italy in 1999. As is discussed in more detail in Section VI on Hatcheries and Commercial Aquaculture, Italy is the only country outside of the United States that is currently believed to have successfully established a commercial aquaculture operation involving white sturgeon. In 1999 and 2000, LEMIS data also recorded the re-import of five shipments of Kootenai River white sturgeon from hatcheries in British Columbia. Table 5.3.9 shows white sturgeon imports between 1998 and 2001 (partial).

Green Sturgeon

British Columbia, the only Canadian province in which the species is extant, prohibits the possession or retention of green sturgeon. The United States allows some limited catch, primarily in Native American fisheries, but the volume is believed to be fairly limited. There is not thought to be a significant market outside of the Native American community for

Table 5.3.9 Reported U.S. White Sturgeon Imports, 1998–2001 (partial)*

Year	Number of Imports	Product	Total Quantity	Unit	Value (US$)	Source	Country	Purpose
1998	4	Meat	240	kg	12,613	W	Great Britain	T
1999	1	Eggs	150	gm	374	R	Italy	T
2000	4	Live	10,000	NO	0	W	Canada	N
	1	Live	698	NO	0	F	Canada	N
	1	Live	600	NO	0	F	Canada	N
	1	Live	750	NO	0	F	Canada	N
2001	1+	Live	100	NO	230	C	Hong Kong	T
	1	Live	1,555	NO	0	F	Canada	N

+ Recorded in LEMIS under the Disposition "A." TRAFFIC surmised that this was likely a shipment of live fish that were seized as an illegal import.

Key: NO = Number—could indicate number of eggs or other; W = wild; F = first generation; C = captive-bred; R = ranched; T = commercial trade; N = noncommercial trade (in this case these are Kootenai River fish re-imported from back-up hatcheries in Canada).

* Source: TRAFFIC analysis of USFWS LEMIS data, February 19, 2002.

green sturgeon meat or caviar, and there is no documented international trade in the species (S. Lieberman, Chief, USFWS/DMA, *in litt*. to Willem Wijnstekers, Secretary General, CITES Secretariat, 2001).

5.4. Illegal Trade

By its very nature, illegal trade in wildlife and wildlife parts is difficult to document. What is known is often anecdotal, or is derived from records of arrests and convictions. Undercover operations to detect and prosecute those involved in the illegal trade of paddlefish and sturgeon products are routinely carried out by state, provincial, and federal authorities, but information on these activities is not available until their successful conclusion. The following summarizes some of what is known, or suspected, about the illegal trade, and is drawn from a variety of sources.

Illegal trade is believed to concentrate on a few acipenseriform species in North America, in both the United States and Canada. Most concern has been expressed about the paddlefish, although there have also been accounts of illegal take and trade involving the Atlantic sturgeon, shortnose sturgeon, pallid sturgeon, lake sturgeon, shovelnose sturgeon, and white sturgeon. Illegal activities involving the green sturgeon most likely involve sport fishing violations (use of illegal gear, violation of size restrictions, possession of fish above the creel limit, etc.) incidental to white sturgeon fisheries. There is not believed to be significant poaching of green sturgeon for commercial sale.

Atlantic Sturgeon and Shortnose Sturgeon

Cases of illegal catch and trade have been reported involving shortnose and Atlantic sturgeon. For example, in 1995, two South Carolina fishermen were apprehended with five pounds of shortnose sturgeon roe and two gravid fish (NMFS 1998). In 1999, four people in Virginia were charged with taking a total of 98 Atlantic sturgeon from the James River, in violation of the state's prohibition on catch, possession, or sale of the species. Under Virginia law, each of the defendants faced misdemeanor charges that carry a maximum penalty of one year in jail and a $2,000 fine (Anon. 1999b). However, cases involving these species are believed to be relatively isolated incidents rather than widely organized activities. Poaching is believed to be more prevalent where legal markets exist from imports, commercial catch, or commercial aquaculture (NMFS 1998).

Paddlefish and Shovelnose Sturgeon

Paddlefish and shovelnose sturgeon are discussed together in this section because commercial fisheries for these species generally occur in the same states, and fishers

involved in illegal catch and trade may target both species.

Responding to questions regarding illegal trade of paddlefish for the CITES Significant Trade Review in 2000, wildlife conservation agencies in U.S. range states provided a variety of replies. Arkansas, where legal trade is allowed but has not been closely monitored in the past, and Ohio and Alabama, where trade is prohibited, responded that there were no reports of poaching and that state authorities were unaware of poaching activities. Wisconsin also reported no known poaching activity, but did note the prosecution of a commercial fisherman for killing more than 60 paddlefish in nets that were set to catch other species. The violation in that case was "waste of a state resource" (K. Scheidegger, Wisconsin Department of Natural Resources, *in litt*. to Rosemarie Gnam, USFWS/OMA, August 17, 2000). South Dakota reported not being aware of poaching activity, and further noted that its population had too few mature individuals to attract poachers at the time of the inquiry (C. Stone, Senior Wildlife Biologist, Reservoir Fisheries, South Dakota Department of Game, Fish and Parks, *in litt*. to Rosemarie Gnam, USFWS/OMA, August 25, 2000). North Dakota reported very little illegal activity (Greg Power, Fisheries Division, North Dakota Game and Fish Department, *in litt*. to Teiko Saito, USFWS/OMA, August 22, 2000). Montana noted that while the state is concerned about the potential for illegal activity, and enforcement efforts are ongoing, no illegal activity had been documented. Montana has cited individuals for over-harvest, high-grading, and other fishing violations (L. Peterman, Administrator, Fisheries Division, Montana Fish, Wildlife and Parks, *in litt*. to Teiko Saito, USFWS/OMA, August 21, 2000).

Kansas reported that while it is likely that illegal catch takes place, the state was not aware of major poaching activities (T. Mosher, Fisheries Research Coordinator, Kansas Department of Wildlife and Parks, *in litt*. to Teiko Saito, USFWS/OMA, August 17, 2000). Illinois reported that suspected illegal activities were believed to focus on under-reporting of commercial catch (M. Conlin, Chief, Division of Fisheries, Illinois Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 23, 2000).

Among states that reported illegal activity, Iowa noted that local law enforcement personnel participated in an investigation to crack down on illegal practices related to the selling of fish and game along the Missouri River. Some of this activity may have involved paddlefish and/or shovelnose sturgeon. The state reported that officials were unaware of illegal activities elsewhere in the state (Marion Conover, Chief, Fisheries Bureau, Iowa Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 14, 2000). Nebraska also reported that there were known paddlefish and sturgeon poaching activities on the Missouri River (Don Gablehouse, Administrator, Fisheries Division, Nebraska Game and Parks Commission, *in litt*. to Rosemarie Gnam, USFWS/OMA, August 21, 2000). Nebraska press reports from 2000 detail a two-year investigation into illegal sale and transportation of wildlife along the Missouri River border that resulted in the issuance of citations to 30 people for nearly 200 wildlife violations, some involving paddlefish poaching. The investigation was initiated because of concern among wildlife agencies that paddlefish were being taken illegally for caviar or purchased from sport fishermen during the October open sport season. There was also concern about the impact poaching may have on endangered species such as the pallid sturgeon (Omaha World Herald, July 20, 2000).

Tennessee reported in 2000 that law enforcement efforts to determine the impact of poaching on paddlefish populations resulted in two commercial fishing violations, two illegal gear violations, and 11 sport fishing violations for taking paddlefish during closed seasons. The state indicated that poaching appeared to be light to moderate during the closed season, but less information was available regarding violations during the open season because enforcement personnel during that period are regularly focused on regulating hunting activities (Robert Todd, Commercial Fishing Coordinator, Tennessee Wildlife Resources Agency, *in litt*. to Teiko Saito, USFWS/OMA, August 21, 2001).

More recently, however, three individuals from Tennessee were prosecuted and found guilty on May 16, 2002 in a significant case involving violations of the Lacey Act and conspiracy to

violate the Lacey Act related to illegal catch and trade of paddlefish roe. Charges included purchasing paddlefish caviar that was harvested from fish caught during closed Tennessee seasons and in closed waters, sale of caviar in interstate commerce that was taken in violation of state laws, purchasing fish without being licensed as a wholesale fish dealer by the State of Tennessee, and creating false documents to conceal the identities of fishermen and locations where the paddlefish eggs were taken. USFWS special agents and wildlife investigators from TWRA worked together to prepare the case. Officers of the Kentucky Department of Fish and Wildlife Resources and the Alabama Division of Wildlife and Freshwater Resources assisted in the investigation (USFWS 2002d).

Their joint investigation determined that over 8,400 pounds (3,818 kg) of paddlefish caviar, with an estimated black market value of US$483,000 (far lower than the ultimate retail value), were illegally taken and sold in interstate commerce by participants in the conspiracy. Two of the individuals involved, Frank and Carolyn Hale, doing business as Royaloff Caviar of Savannah, Tennessee, were found guilty of six felony violations of the Lacey Act and conspiracy to violate the Lacey Act. The third individual, Wendy Haney-Melson, daughter of Frank and Carolyn Hale, was found guilty of conspiracy to violate the Lacey Act for her role in creating false documents and purchasing paddlefish caviar taken during closed seasons and in closed waters. Sentencing, originally scheduled for August 12, 2002, was delayed until at least Spring of 2003, so the ultimate disposition of the case is not known at the time of this report. This was the fifth conviction resulting from an intensive investigation into illegal paddlefish trade by USFWS and state agencies in the Southeast (USFWS 2002d).

Louisiana responded to the 2000 CITES Significant Trade review process that poaching activities are always a possibility because of the potential for making large amounts of unreported money in the illicit caviar trade. The state's respondent noted an anecdote relayed by the Chief of Tennessee Fisheries to the Louisiana Department of Wildlife and Fisheries, of a man who wanted a permit from Tennessee to transport, and then export, 5,000 pounds of paddlefish roe per month. When asked the source, the man said "Louisiana" (John Roussel, Assistant Secretary, Office of Fisheries, Louisiana Department of Wildlife and Fisheries, *in litt*. to Teiko Saito, USFWS/OMA, August 25, 2000). It is impossible to substantiate the truth of this story; however, it is typical of the anecdotes and rumors that abound concerning roe fisheries.

Mississippi responded that there is known illegal catch of paddlefish in the state, and law enforcement cases were pending at the time of the inquiry. Apprehension of suspects, however, has proved difficult, as the activity is organized and highly secretive. Poaching and illegal catch in Mississippi may be a continuing problem, but the full extent of illegal activity is unknown.

Kentucky, Missouri, and Oklahoma did not respond directly to the question regarding illegal trade. A TRAFFIC review of news items in Oklahoma did turn up cases of documented illegal activity. In July 2000, for example, Oklahoma wildlife officials expressed concern that increasing prices for caviar might be enticing poachers to illegally catch and sell paddlefish roe, citing an incident in which more than 40 fish were found that had been slit open in search of roe, in one night (The Journal, United Kingdom, July 15, 2000). A 2001 case involved eight Claremore, Oklahoma, area residents, who were arrested on state and federal charges for illegal take and commercialization of paddlefish, following a joint investigation between USFWS and the Oklahoma Department of Wildlife Conservation. Four people were charged with conspiring from February to June 2000 to take excessive amounts of paddlefish from Oklahoma lakes and rivers, and arranging for the eggs to be iced and transported across state lines into Arkansas. Two of the defendants were further charged on May 17, 2000 with transporting 150 pounds of paddlefish eggs across state lines. Federal charges in the case included conspiracy, aiding and abetting, and violations of the Lacey Act. Four additional people were arrested on state charges, because wildlife law enforcement officers documented approximately 120 state wildlife violations, including snagging in a restricted area,

abandoning paddlefish without proper disposal, and exceeding the legal limit for the species (USFWS 2001f; Tulsa World 2001).

Beyond poaching and illegal trade of paddlefish and shovelnose sturgeon in the Mississippi Basin, another illegal activity involving mislabeling of paddlefish and shovelnose caviar has begun to raise serious concerns among wildlife management agencies, law enforcement officials, and conservationists. To date, the largest example and conviction of this practice came to light in 2000, when the owner and several employees of Maryland-based U.S. Caviar & Caviar, Ltd. (hereinafter, U.S. Caviar) pleaded guilty to multiple counts of conspiracy, smuggling, making false statements, submitting false wildlife records, mail fraud, and violations of the Endangered Species Act and the Lacey Act.

The activities, all federal felony charges, fell into two categories. In the first set of violations, U.S. Caviar admitted importing tons of black market caviar into the United States from the United Arab Emirates using forged Russian caviar labels. The labels made it appear as if the roe had been produced and exported by a large, legitimate Russian caviar supplier, when in fact it had been smuggled out of Russia and other countries bordering the Caspian Sea. The forged labels (at least 5,000) were produced at U.S. Caviar's Rockville, Maryland, headquarters, and sent to the United Arab Emirates for use on caviar shipments to the United States. The company and its co-defendants forged wildlife documents, including Russian health certificates, to further authenticate their shipments, which were accompanied by false CITES permits, customs documents, invoices, and packing lists. In 1998 alone, U.S. Caviar imported approximately 18,000 pounds (9 tons; 8.1 metric tons) of caviar from the United Arab Emirates using false labels and documents. U.S. Caviar also smuggled authentic Russian Beluga caviar into the United States by labeling the tins as less valuable caviar, filing false declarations, and using false invoices understating the value of the caviar to avoid paying the higher customs duty required (USFWS 2001g).

In the second set of violations, U.S. Caviar and its co-defendants operated a mail fraud scheme that sold mislabeled North American roe to U.S. customers as Russian Sevruga caviar, a highly prized and more expensive Caspian Sea roe. DNA tests conducted by the USFWS National Fish and Wildlife Forensics Laboratory in Ashland, Oregon confirmed that the purported "Russian" caviar was really paddlefish and shovelnose sturgeon roe from sources in the Mississippi River Basin. Bilked customers included major airlines, gourmet grocery chains, and cruise lines.

U.S. Caviar pleaded guilty to 22 federal charges. Hossein Lolavar, U.S. Caviar's owner and president, pleaded guilty to 12 federal charges. Lolavar was sentenced to 41 months in federal prison, U.S. Caviar's sales manager received a 21-month sentence, and the president of the caviar export firm operating out of the United Arab Emirates received 15 months in prison. In addition, U.S. Caviar was fined US$10.4 million, the largest fine ever imposed in the United States for a wildlife trafficking case (USFWS 2001c).

Smuggling Russian caviar is disturbing, but certainly not unique. In two other cases, decided in 1999 and 2001, individuals were found guilty of, or pleaded guilty to, illegally bringing thousands of pounds of Caspian Sea caviar into the United States. In the 2001 case, a Russian citizen was caught attempting to smuggle 1,700 pounds of caviar in containers mislabeled as dried fish (USFWS 1999a, 2001g). The difference in the U.S. Caviar case was the intentional use of paddlefish and shovelnose sturgeon as substitutes for more expensive and highly prized Russian caviar.

In a similar case, the U.S. Justice Department recently announced the sentencing of Alfred Yazbak, the President and owner of Connoisseur Brands Ltd., for conspiring to smuggle protected sturgeon caviar and selling falsely labeled caviar to retail food companies. A USFWS special agent posing as a buyer for a gourmet food store purchased caviar from Connoisseur, which upon testing proved to be paddlefish roe. Yazbak received a sentence of two years in prison, an individual fine of US$26,404, and was ordered to pay US$23,594 in restitution for unpaid customs

duties for the smuggled caviar (a combined total of US$50,000). New York–based Connoisseur Brands was ordered to pay a criminal fine of US$110,000, which included a community service payment of US$25,000 to the Fish and Wildlife Foundation for the preservation and restoration of sturgeon and paddlefish (TRAFFIC North America 2002).

As previously noted, a contributing factor that makes the mislabeling of roe lucrative is the difference in value between caviar from North American species and those of Caspian Sea species. In 2001 caviar from paddlefish and shovelnose sturgeon retailed in legal markets for approximately $10 per ounce. Caviar from premium Caspian Sea sturgeon, on the other hand, can retail for well over $100 per ounce. Thus, selling mislabeled North American caviar can significantly multiply the profits for those involved in the crime. It is not fully known whether the cases cited above are isolated incidents or part of more common schemes to exploit North American species and sell their roe under false pretenses. If it is a common occurrence, the economic incentives to catch paddlefish, shovelnose sturgeon, and other North American species for sale under false Caspian Sea labels would pose yet another threat to North American populations. Fortunately, the USFWS National Fish and Wildlife Forensic Laboratory continues to refine its methods for typing caviar to species, using DNA analysis, so that samples of falsely labeled caviar may be quickly detected when tested (Fain 1999).

Lake Sturgeon

Although most of the illegal trade in the mid- to southern Mississippi River basin in the United States appears to involve paddlefish and shovelnose sturgeon, in the northern reaches of the basin and in the Great Lakes region, there have also been recorded cases of illegal catch and trade involving lake sturgeon.

Responding to the 2000 CITES Significant Trade Review inquiry, almost all of the states mentioned previously in the species' historic southern range either had no records of illegal catch or trade of lake sturgeon, or reported that any such activity was most likely incidental to the illegal catch of other species. The lack of significant illegal trade is believed to reflect the decrease in stocks throughout much of the lake sturgeon's range, which would make it unlucrative as a specific target for poachers.

In the northern segment of the lake sturgeon's U.S. range, Ohio reported no known poaching or illegal trade activities in Ohio's portion of Lake Erie. Michigan reported known illegal catch activities, particularly in spawning areas. The areas with the greatest illegal activity were reported to be Michigan's St. Clair River, the Black River upstream from Black Lake, and the Sturgeon River in Baraga County, Michigan. State authorities noted that Department of Natural Resources personnel are taking active measures to enforce regulations, and are also actively seeking the help of citizen volunteers such as the "Sturgeon for Tomorrow" group, located on the Black River (Gary Whelan, Fish Production Manager, Michigan Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 29, 2000). The Sturgeon for Tomorrow initiative has been active since 1977. Under the initiative, volunteer guards observe spawning sites for 24-hour shifts during the spring spawning runs, to provide a significant deterrent to poaching activities (Bruch 1999).

In spring 2000, the Michigan Department of Natural Resources (DNR) arrested and successfully prosecuted three individuals for illegally taking three lake sturgeon from the Sturgeon River. Two of the defendants each received a sentence of 30 days in jail, and were barred from obtaining a fishing license for seven years. Each was also ordered to pay $1,500 in restitution and $1,200 in fines and court costs. The third defendant, who described the events to authorities, received a sentence of 10 days in jail, was ordered to pay $750 in restitution and $1,200 in fines and court costs, and lost the right to obtain a fishing license for four years (Nancy Auer, *in litt*. to Andrea Gaski, USFWS/DMA, September 11, 2000). In the spring of 2001, a man pleaded guilty to taking a lake sturgeon from Lake St. Clair, in an area known as "the sturgeon hole," and later hiding it in his car. For taking a sturgeon during the closed season, he received a $2,000 fine, was ordered to pay $1,500 in restitution, and was sentenced to 30 days in jail. It is not known

whether these are isolated incidents, but Michigan DNR noted that similar enforcement efforts continue. The stiff penalties in these cases indicate that the Michigan judicial system views lake sturgeon poaching as a serious offense (The Macomb Daily 2001).

Minnesota reported that state authorities believe that illegal activities do occur, but their extent was unknown. A summary of violations between 1997 and 2000 included three summonses and five warnings for fishing without a license; one summons and two warnings for fishing during a closed season; one summons for fishing with illegal equipment or in an illegal manner; two summonses for taking fish below the legal length limit; one warning for no license in possession; three summonses and one warning for fishing in a closed area; and one summons for exceeding the legal length limit (Linda Erickson-Eastwood, Fisheries Program Manager, Minnesota Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 23, 2000). There were no documented law enforcement cases or prosecutions involving illegal lake sturgeon trade.

Wisconsin reported no known cases of illegal catch or trade of lake sturgeon as of 2000.

Unfortunately, very little information is available about illegal take and trade of lake sturgeon in Canadian waters. None of the provinces contacted for the 2000 CITES Significant Trade review provided data on the subject. A 2002 inquiry to DFO by TRAFFIC's Canadian representative also indicated that illegal catch and trade have not been raised as a major concern or threat regarding lake sturgeon (pers. comm., E. Cooper, TRAFFIC North America Canada Representative, August 29, 2002).

To date, there have been no known cases of lake sturgeon roe being mislabeled and sold as Caspian Sea or other sturgeon caviar. This may be because the primary current market for lake sturgeon involves meat rather than roe. However, given the high value placed on lake sturgeon caviar historically, and the growing demand for North American caviar, this circumstance may change and should be monitored.

White Sturgeon

Documented illegal activities involving white sturgeon in recent years are largely categorized as fisheries violations in both the United States and Canada, although there have been cases of illegal trade.

In California, for example, there has been periodic evidence of poachers targeting gravid female white sturgeon for their roe in the Sacramento-San Joaquin River Basin. As far back as the mid-1980s, law enforcement officials noted the take of oversized white sturgeon from the Columbia River's Bonneville Pool, presumably for roe. In a significant U.S. case in 1993, two Washington state fishermen and a New Jersey caviar distributor were indicted for illegally harvesting 3,200 pounds of Columbia River caviar, worth at least US$2.5 million, and selling it to a distributing company in New Jersey. This caviar, supplied from illegally caught sturgeon over a five-year period, equaled the entire state of Washington's legal caviar take, which was estimated during those years at approximately 650 pounds annually. Charges were eventually dropped against one of the fishermen, while the other, who testified on behalf of the state, pled guilty to violating the Lacey Act and received a sentence of eight months in prison and a US$2,500 fine. The owner of the distributing company was found guilty of obstruction of justice and misdemeanor violations of the Lacey Act, and was sentenced to 18 months in prison and a US$4,000 fine. His company received a US$20,000 fine (Hoover 1996).

In Canada, recent press reports discussed several cases of illegal trade and/or possession, although there were no documented connections to the caviar trade. In one case, a restaurant was fined $7,000 for illegally buying white sturgeon after a customer reported the fish on the restaurant's menu. In another case, a couple was charged with illegal possession of white sturgeon, after three fish were found in their vehicle during a traffic stop; the largest fish was almost 6 feet long and weighed 45 kilograms (99 pounds) (The Vancouver Sun 2001). A Vancouver resident was ordered to pay $5,000CAD in yet another case, after pleading guilty to one count of illegal possession of sturgeon. The guilty plea

resulted from a joint investigation of sturgeon poaching on the Fraser River by local district conservation officers and the Canadian DFO. On September 13, 2000, night surveillance of set lines in the Fraser River resulted in the seizure of six live sturgeon and the arrest of two individuals (M2 Presswire 2000, 2001).

Overall, illegal trade has not appeared to present a significant problem for the management of wild white sturgeon populations to date. However, the recent increase in demand for the roe of North American sturgeon species as an alternative to imported caviar may target some North American species, and requires vigilant monitoring of catch and trade of all species by the law enforcement community.

VI. HATCHERIES AND COMMERCIAL AQUACULTURE

Captive propagation and commercial aquaculture have come to play a central role in discussions of how best to conserve North American paddlefish and sturgeon species. As discussed here, captive propagation and commercial aquaculture are separate, distinct activities. In this document, captive propagation refers to efforts to spawn and rear threatened, endangered, vulnerable, or genetically valuable fish species for scientific study, reintroduction, restoration, or stocking programs. It is conducted primarily, but not exclusively, by state and federal fish hatcheries and research facilities.[1] Commercial aquaculture, sometimes referred to as "fish farming," propagates and raises fish primarily for commercial purposes as an addition or alternative to wild catch, and is conducted primarily by private companies or individuals.

To date, the majority of both captive propagation and commercial aquaculture activities in North America have taken place in the United States. Federal fish hatcheries across the continental United States are engaged in captive propagation of North American Acipenseriformes, as well as research and other activities to promote their conservation. The USFWS Fisheries Program and National Fish Hatchery System (NFHS) have been involved in the captive propagation of nine native acipenseriform species: the Alabama sturgeon, Atlantic sturgeon, Gulf sturgeon, lake sturgeon, paddlefish, shovelnose sturgeon, pallid sturgeon, shortnose sturgeon, and white sturgeon. A number of state fish hatcheries are also engaged in captive propagation efforts, most commonly involving paddlefish and lake sturgeon, which are generally geared toward efforts to restore or reintroduce these species through stocking operations in selected waters. Commercial aquaculture ventures in the United States concentrate primarily on the paddlefish and white sturgeon, although some operations target lake sturgeon, and approval was recently granted for an Atlantic sturgeon operation in Florida.

In Canada, in recent years the British Columbia Ministry of Environment has undertaken hatchery-based efforts to restore endangered white sturgeon stocks, including providing facilities to rear specimens of the U.S. population of Kootenai River white sturgeon. Manitoba and Saskatchewan have conducted some limited propagation and/or stocking of lake sturgeon in selected areas. Commercial aquaculture of Atlantic sturgeon is underway in New Brunswick, and there are commercial operations licensed to rear lake sturgeon in Ontario. There have also been recent indications of interest in commercially rearing white sturgeon in British Columbia.

As of 2001, there was no known captive propagation or commercial aquaculture of green sturgeon in the United States or Canada. As noted in previous sections, this species is not well understood and not considered particularly valuable commercially. There are green sturgeon in captivity, but activities involving these fish appear to be focused on basic research.

This section summarizes the status of various captive propagation programs and commercial aquaculture ventures in the United States and Canada. It also examines some of the issues concerning roles and possible effects that both practices may have on the conservation, management, and trade in wild North American Acipenseriformes.

6.1 Captive Propagation

In the United States, USFWS, state fish hatcheries, and private and public partners are engaged in numerous initiatives to propagate paddlefish and sturgeon species in captivity for reintroduction, restoration, and research

[1] University research and scientific programs are not extensively addressed here.

purposes. Some of these activities are the sole responsibility of specific agencies, while others are joint projects involving public agencies and private entities. In Canada, captive propagation of sturgeon falls primarily under the jurisdiction of provincial wildlife and fisheries agencies.

Federal involvement in captive propagation within the United States is largely managed under the purview of the USFWS Fisheries Program, which comprises a network of Fisheries Management Offices and the NFHS. Together they provide on-the-ground fisheries expertise and management capability nationwide. Fisheries Program activities operate under six priorities: recovery of ESA-listed and candidate aquatic species; restoration of depleted aquatic populations to preclude formal listing; restoration of inter-jurisdictional fisheries and aquatic ecosystems; management of inter-jurisdictional fisheries; fulfilling mitigation responsibilities; and providing USFWS management assistance to Native American tribes and for USFWS property. The NFHS includes 66 Fish Hatcheries, seven Fish Technology Centers (FTC), and nine Fish Health Centers (FHC). FTCs and FHCs provide technical support to Fish Hatcheries and other federal, state, and private partners in the recovery and restoration of sturgeon and other species. Together, these components play several roles in restoring sturgeon and paddlefish, including: (1) propagating imperiled sturgeon in captivity to produce genetically appropriate fish for reintroduction; (2) developing technologies for holding, propagating, and conducting post-stock evaluations of imperiled species; (3) providing fish health diagnostics for both hatchery-reared and imperiled wild sturgeon populations; and (4) maintaining imperiled sturgeon in refugia until conditions are suitable for their reintroduction into the wild (Andreasen 1999).

For this report, USFWS provided TRAFFIC with a summary of projects regarding sturgeon and paddlefish in Fiscal Year (FY) 2000[2] undertaken by the Fisheries Program (USFWS/Fisheries Information System [FIS] 2001). TRAFFIC also reviewed information provided for the CITES Significant Trade Reviews of several North American Acipenseriformes and other reports and documents to compile the information presented herein, as well as surveying state, provincial, and federal fisheries agencies by telephone as necessary to answer questions about specific species and programs. It should be noted that the species summaries below are merely a thumbnail sketch of the many wide-ranging and complex activities conducted for the captive propagation of sturgeon and paddlefish in North America. They are included here to illustrate the importance of captive propagation programs to the conservation of several North American acipenseriform species. As in other sections of this report, TRAFFIC devotes particular attention to species that are in trade. Because captive propagation of sturgeon is less prevalent in Canada (e.g., there is no captive propagation or stocking of Atlantic and shortnose sturgeon), several of the species summaries also tend to focus on U.S. activities. Some of the potential benefits and drawbacks of captive propagation programs for North American sturgeon and paddlefish species are briefly discussed in Section 6.3.

Atlantic Sturgeon

In the United States, one of the management objectives in the 1990 ASMFC Fishery Management Plan (FMP) for Atlantic sturgeon was to "enhance and restore Atlantic sturgeon stocks." To that end, the FMP included three specific recommendations: (1) encourage an expanded aquaculture effort to develop techniques to rear Atlantic sturgeon and evaluate hatchery fish for stock restoration; (2) encourage aquaculture research to identify and control early life stage diseases, synchronize spawning times of males and females, and reduce handling stress problems; and (3) establish an aquaculture and stocking committee to provide guidelines for aquaculture and restoration stocking of sturgeon (ASMFC 1996, 1998b).

In response to the first two recommendations, the USFWS Northeast Fishery Center (NEFC) in Lamar, Pennsylvania, initiated Atlantic

[2] The U.S. Fiscal Year runs from October 1 to September 30 of each year. FY 2000 began in October 1999 and ended in September 2000.

sturgeon propagation research in 1991. In collaboration with the National Biological Service Laboratory—which has since become the U.S. Geological Survey, Biological Resources Division—in Wellsborough, Pennsylvania, and others, NEFC collected broodfish from the Hudson River in 1991 and again from 1993 through 1996. Sub-adult Atlantic sturgeon were also held on-site at Lamar beginning in 1991, and males from this source were induced to spermiate in 1997. Adult handling, hauling, and holding capacity, as well as short-term sperm preservation techniques were refined, and hormone-induced spawning with surgical removal of eggs, fertilization, egg de-adhesion and incubation, and larval and juvenile culture methods were adapted and modified from techniques developed for white sturgeon (ASMFC 1998b). Experimental sturgeon culture was also conducted during the 1990s by USFWS and the National Biological Service at sites in Massachusetts, Virginia, and South Carolina (ASMFC 1996).

Small numbers of Atlantic sturgeon were produced during the 1990s at the Lamar NEFC, and contributed to numerous cooperative research studies. Work included investigations on feed types and feeding rates, desirable rearing densities and water quality parameters, disease challenges and treatments, and marking studies. Juvenile sturgeon not necessary for research were stocked with state permission into the Hudson River in 1994 (5,000 at approximately three months of age) and the Nanticoke River in Maryland in 1996 (3,500 at one year of age). All fish were marked with coded wire tags, and the Hudson River fish were also fin-clipped. Although these were not considered "restoration" stockings, the fish have provided useful information about movements, distribution, and growth of young sturgeon. The relative frequency of cultured and wild fish in Hudson River juvenile collections was also used to document low natural recruitment levels in that river (ASMFC 1998b).

Also in 1991, in response to the third recommendation of the 1990 FMP, an Atlantic Sturgeon Aquaculture and Stocking Committee (ASASC) was established. The Committee presented 34 recommendations related to the culture and stocking of Atlantic sturgeon to the ASMFC Management and Science Committee in 1992 in a report titled "Recommendations Concerning the Culture and Stocking of Atlantic Sturgeon" [ASMFC (1992), cited in ASMFC (1998b)]. These were grouped into six general categories, including aquaculture research and development; collection of broodstock and release of cultured progeny; translocation of sturgeons and inadvertent spread of diseases; introduction of non-native sturgeons for commercial aquaculture; collection and archiving of tissue samples for genetic analysis; and monitoring and effectiveness of restoration programs (ASMFC 1998b).

Many of the recommendations in the 1992 report encouraged state and federal agencies to develop techniques for broodfish collection and holding, induced spawning and sperm preservation, incubation, hatching, and rearing of Atlantic sturgeon. Recommendations for stocking the cultured fish or excess wild broodfish, however, were cautious because of concerns about maintaining the genetic integrity of wild stocks, maintaining effective breeding populations, and preventing genetically harmful inbreeding. The recommendations included the following: (1) if management units are defined by river, then genetic integrity of stocks within river basins should be maintained by stocking only progeny of native broodstock; (2) if genetic substructure exists, then restoration programs should employ only genetically compatible stocking (i.e., reintroduction of progeny cultured from one stock into waters inhabited by that same stock); (3) if native broodstock no longer exist, or are in such low abundance as to preclude effective collection, priority should be given to stocking fish from adjacent, hydrologically similar river systems; (4) broodstock should be collected at times and in numbers that do not unduly stress the native population, yet adequately represent the inherent variation of that stock; and (5) an adequate, effective breeding population size should be maintained to the extent possible in culturing Atlantic sturgeon for restoration purposes so that the genetic integrity of the local recipient stock is maintained (ASMFC 1996).

In a follow up to that report, the ASASC prepared, and in 1996 presented, an ASMFC Breeding and Stocking Protocol for Cultured

Atlantic Sturgeon. Its purpose was to further review and recommend culture and stocking strategies for Atlantic sturgeon, based upon the earlier identified need to more completely evaluate the role of captive propagation and aquaculture in Atlantic sturgeon recovery (ASMFC 1996).

The 1996 protocol made eight specific recommendations that built upon those made in the 1992 report. These included, in sum and substance, the following:

- Whenever possible, use broodfish from the same river in which stocking will occur. When this is not possible, the source of broodfish used to culture progeny should be taken from the same regional grouping as the area being stocked.
- With regard to stocking programs, highest priority should be given to populations perceived to be extirpated, and a secondary priority should be given to populations exhibiting little, if any, natural reproduction.
- The minimum generation effective population size of broodfish used in culture for stocking programs should be 100 (with an inbreeding rate of 0.50%), year-class effective population sizes should be at least six (preferably three of each sex, although year-class effective population sizes of six or greater may be obtained using unbalanced sex ratios), but sperm from multiple male spawners should not be mixed for artificial fertilization.
- Fishery agencies involved with stocking programs for Atlantic sturgeon should commit to the necessary number of years of stocking to achieve the targeted generation effective population size.
- If fewer breeding fish are available than prescribed in recommendation 3, their progeny may be used for captive research (i.e., not released into public waters) or provided to private aquaculture interests for captive use.
- Broodfish should be spawned only once, and healthy survivors should be externally marked and returned to their river of origin whenever feasible.
- In order to avoid gene swamping from small numbers of breeding pairs, numbers of progeny stocked from individual matings in any one year should be within 50% of each other, not to exceed 50,000 fish per pair for each receiving water, and all fish destined for stocking should be distinctively marked or tagged to at least indicate release location, time, and parental origin.
- Management jurisdictions involved in culture and stocking programs for Atlantic sturgeon for research or restoration purposes should annually monitor the status of their populations and the effects of stocking, provide a detailed proposal to ASMFC for review and approval, and report monitoring results to ASMFC by July 1 of each year (ASMFC 1996).
- The 1996 ASMFC protocol also included a table outlining suggested potential Atlantic sturgeon donor stocks, and receiving rivers, along the U.S. Atlantic coast, which is recreated in Table 6.1.1.

Since 1996, research has continued on the culture and captive propagation of Atlantic sturgeon. As of FY 2000, USFWS studies in Florida facilities were testing reformulated feeds that support high levels of growth and survival of Atlantic and Gulf sturgeon. Food was produced at the Bozeman FTC in Montana and shipped to cooperators for use in agreed upon studies. Work also continued at the Lamar FTC in Pennsylvania to develop culture technology and determine growth and survival of fry and fingerling Atlantic sturgeon reared at various stocking densities and fed various diets (USFWS/FIS 2001).

Gulf Sturgeon

Successful captive propagation of Gulf sturgeon was first accomplished in 1989 at a portable hatchery located on the Suwannee River and at the Welaka NFH in Florida. The project, a joint effort involving USFWS, the Caribbean Conservation Corperation (CCC), and the University of California at Davis, employed hormone-induced ovulation and spawning to produce 5,000 fry for fishery research. In 1989, artificial feeding programs for Gulf sturgeon were also developed at the

Table 6.1.1 Suggested Atlantic Sturgeon Donor Broodfish Populations for Use in Culture and Stocking Programs in Select Atlantic Coast Tributaries*

Donor Stocks	Receiving Rivers	Priority
Saint John River	Kennebec	High
	Androscoggin	High
	Other ME/NH rivers	High
	Merrimack High	High
Hudson River	Hudson	Low
	Connecticut, Long Island Tributaries	High
	Delaware	High
	Chesapeake Bay	High
Delaware River	Chesapeake Bay and tributaries	High
	Delaware	High
Cape Fear, other NC, Altamaha, ACE Basin, Winyah Bay system	Cape Fear, other NC	High
	St. Marys, Savannah	High
	Altamaha, Ogeechee, Satilla	Medium
	Waccamaw/PeeDee	Medium
	Ashepoo, Combahee, Edisto	High
	Santee, St. John	High

* Source: ASMFC (1996).

Welaka NFH and at the Warm Springs Regional Fisheries Center in Georgia. In 1990, 1991, and 1992, the University of Florida, USFWS, and CCC again induced spawning and produced approximately 60,000 further fry for fish culture programs. In 1992 and 1993, captive propagation efforts also took place at the National Biological Service, Southeastern Biological Science Center in Gainesville, Florida (USFWS/GSMFC 1995). Captive propagation and research continued at some of these facilities throughout the 1990s.

The 1995 Gulf Sturgeon Management/ Recovery Plan recognized the potential benefits of captive propagation for the species, but, as is the case with other North American sturgeons, also recognized the need for caution and clear protocols in the development of captive propagation programs. Among the recommendations in the plan was one that encouraged state, federal, and nongovernmental agencies to continue to develop culture techniques for Gulf sturgeon, in accordance with Gulf Sturgeon Hatchery Guidelines, protocols in the Hatchery Manual for White Sturgeon addressed in the plan, and federal and state laws and regulations. The plan further noted the need to identify the physical, chemical, and biological parameters necessary to maintain the growth, health, and survival of captive-reared Gulf sturgeon, as well as the need to identify and test external markers or techniques to differentiate between wild and hatchery-produced fish (USFWS/GSMFC 1995).

The 1995 plan was similarly cautious on the question of stocking hatchery-reared Gulf sturgeon as a component of the species' recovery effort. The plan recommended assessing whether such stocking would benefit the overall recovery of the Gulf sturgeon, and conducting an evaluation of whether rivers that might be stocked have suitable habitat to support stocked fish, natural reproduction, and any progeny. It further noted that stocking should be secondary to other recovery efforts that identify essential sturgeon habitats and emphasize habitat restoration, and that Gulf states resource management agencies, GSMFC, USFWS, NMFS, nongovernmental organizations, universities, and other involved researchers should prepare a hatchery and culture operations plan relating to stocking policy and guidelines. As with other sturgeon

species, the plan was sensitive to the need to maintain the genetic integrity of both wild and hatchery-reared stocks (USFWS/GSMFC 1995).

In a report for the Florida Fish and Wildlife Conservation Commission, Wakeford (2001) noted that discussions were ongoing about the pros and cons of a stocking program for Gulf sturgeon in Florida. The report pointed to a difficult conundrum for the fisheries agencies involved. Stocking in order to restore Gulf sturgeon populations would be feasible only if broodstock could be obtained without depleting the native Gulf sturgeon population to the point that natural reproduction is affected; however, it cannot be assumed that small populations can be completely restored or rehabilitated through natural reproduction alone. Furthermore, stocking can be successful only if habitats are present for Gulf sturgeon in all life history stages, if the hatchery-reared sturgeon survive and reproduce, if the introduced fish do not outcompete or displace native sturgeon and other native fish species in the ecosystem, and if hatchery-reared sturgeon to be stocked are genetically appropriate for the river systems and physically healthy. Wakeford reported that a Florida Sturgeon Culture Risk Assessment Workshop in 2000 led to a "popular opinion" that a State of Florida Stock Restoration Plan is needed for native sturgeon species, consistent with their overall recovery plans.

While many issues and questions remain under consideration, work has proceeded on captive propagation of Gulf sturgeon. USFWS/FIS (2001) reported that, as of FY 2000, the Welaka NFH in Florida held 1,200 Gulf sturgeon,[3] of two year-classes, for future broodstock, captive propagation, and research needs. Efforts were underway to determine migration patterns and habitat preference types for the Suwanee River wild population through the use of sonic and radio tags which are placed on sturgeon that are captured and then released. Tag retention has been a major concern. Therefore, 10 sturgeon of the 1995 year-class have been used in a tag retention study in cooperation with the Panama City Fisheries Resource Office (FRO). These fish were tagged with various experimental fasteners placed on different body locations; retention rates are being monitored. Length and weight differences between tagged and untagged fish are also being recorded. In addition, 45 fish from the 1995 year-class are being raised to determine the rate of sexual maturation in a hatchery environment (USFWS/FIS 2001).

In 2001, other reported captive Gulf sturgeon populations included 570 at the University of Florida at Gainesville, 596 at the University of Florida in Blountstown, 7 at the Lowry Park Zoo in Tampa, and 4 at the Florida Aquarium in Tampa (Wakeford 2001). Also as of 2000, Louisiana was searching for broodstock to begin captive propagation of Gulf sturgeon for recovery purposes (J. Roussel, Assistant Secretary, Office of Fisheries, Louisiana Department of Wildlife and Fisheries, *in litt*. to Teiko Saito, USFWS/OMA, August 25, 2000).

Shortnose Sturgeon

The December 1998 NMFS Final Recovery Plan for the Shortnose Sturgeon (*Acipenser brevirostrum*) included several recommendations related to captive propagation and stocking. The first recommendation recognized the need to develop a breeding and stocking protocol for the species, to ensure that the best possible practices are used in the production of fish for stocking should NMFS determine that it is needed for recovery purposes. Because the shortnose sturgeon is an ESA-listed species, the plan noted that such a protocol must be consistent with NMFS policy on artificial propagation of threatened and endangered species under the ESA. Furthermore, NMFS recommended that procedures should follow the 1992 Breeding and Stocking Protocol for Cultured Atlantic Sturgeon, that culture practices should follow known natural conditions, and that donor stocks should be carefully selected to best match the life history of the fish from the recipient river system and minimize impacts of stocked fish that stray into areas where wild shortnose sturgeon occur (NMFS 1998).

The 1998 recovery plan also recommended consideration of reintroducing captive-

[3] Wakeford (2001) reported that Welaka NFH had 1,156 Gulf sturgeon.

propagated shortnose sturgeon into river systems where the species is extirpated (or may be so rare that the population is functionally extirpated). To guide such efforts, first steps would be to establish the minimum population size below which restoration would be considered, and to determine that sufficient habitat is available for all life stages if NMFS concludes that reintroduction is appropriate. All stocked fish should be tagged to allow monitoring of survival, distribution, movement patterns, growth, and reproduction. The plan emphasized that reintroductions should be conducted only when funds are available to monitor the success of the restoration effort (NMFS 1998).

Finally, the 1998 recovery plan recommended assessing the need for augmenting extant shortnose sturgeon population segments with stocked fish, but only under very specific circumstances. Similar to other sturgeon species, NMFS noted that "the tremendous potential for damage to the genetic architecture of existing population segments demands that extreme caution be used in augmentation efforts" (NMFS 1998). Therefore, according to the recovery plan, if a shortnose sturgeon population segment is found to have an unusually low abundance of spawning adults or juveniles, relative to available critical habitat, causes for the low abundance should be determined. If the problem is found to relate to a correctable habitat condition, the problem should be remedied in a timely manner to prevent extirpation. Short-term stocking of captive-propagated fish should be used to augment an existing population when doing so is the only reasonable manipulation that can prevent loss of the population.

Furthermore, the NMFS plan supported shortnose sturgeon stock augmentation only under a specific set of circumstances: (1) an NMFS-approved breeding and stocking protocol is available to guide programs; (2) an existing population segment is in imminent danger of extirpation; (3) essential habitats are functional but inaccessible to shortnose sturgeon; (4) an obstruction to movement cannot be removed in time to prevent extirpation; (5) cultured fish from the natal population are available; (6) short-term stocking is the only reasonable measure to prevent loss of the population segment; and (7) any stocking effort has been approved by NMFS and a recovery implementation team. Also, in contrast to the 1996 Breeding and Stocking Protocol for Atlantic Sturgeon, stocking of shortnose sturgeon should be conducted for only a brief period to minimize potential effects of stocked fish on the wild stock, during which time a high priority would be placed on minimizing or eliminating the factors that caused the low population abundance. In addition, all stocked fish must be tagged to enable future identification and to allow comparisons of the population dynamics and behavior of stocked fish to wild shortnose sturgeon (NMFS 1998)

It should be noted that stocking of shortnose sturgeon has occurred prior to preparation and publication of the 1998 recovery plan. For example, from 1984 to 1992 approximately 97,000 shortnose sturgeon of various sizes (19% tagged) were stocked in the Savannah River along the South Carolina/Georgia border, to evaluate the potential for stock enhancement [Smith and Jenkins (1991), cited in NMFS (1998)]. A 2000 study of adult shortnose sturgeon in the Savannah River suggested that the river's population was much higher than it had been in 1992, which was attributed to the stock enhancement program rather than to improved recruitment (Collins et al. 2001). Natural recruitment was believed to have remained low, primarily as a result of adult bycatch in shad and shrimp fisheries, and water quality degradation in the nursery habitat of juveniles [Collins et al. (2000), cited in Collins et al. (2001)].

Recently, Welaka NFH in Florida has worked with the state of Florida to determine the feasibility of recovering shortnose sturgeon in the St. Johns River. The shortnose sturgeon had a historical population in the river, which is believed to be extirpated. The elimination of the net fishery in inland waters and the proposed removal of a dam that blocks historic spawning areas have generated interest between USFWS and the state for restoring the species within its native range. Activities up to FY 2000 centered around obtaining the permits required to work with shortnose sturgeon, as well as the development of a river sampling protocol to determine if any remnant

populations survive in the river. The protocol was developed by NMFS, and work began in FY 2001 (USFWS/FIS 2001).

Also, in FY 2000, Bears Bluff NFH in South Carolina produced 103,000 shortnose sturgeon fry for research efforts that included: (1) completion of a captive shortnose sturgeon spawning and conditioning protocol; (2) continuing the development of a protocol for the production of triploid sturgeon to be used as sentinel fish; (3) continuing the development of cryopreservation techniques for shortnose sturgeon; (4) developing anesthetic techniques for brood sturgeon; (5) testing a new egg hatching and fingerling rearing system; (6) testing new broodstock feeds and evaluating behavioral response to new feeds; and (7) testing new feeds and feeding regimes for a shortnose sturgeon fry and egg development/fertility study (USFWS/FIS 2001).

Orangeburg NFH, also in South Carolina, maintained 3,000 captive shortnose sturgeon broodstock during FY 2000 for research and development purposes. In addition, the Warm Springs FHC evaluated new anesthetic and culture techniques for sturgeon species, and developed methodologies for collecting necessary physiological data (USFWS/FIS 2001).

Paddlefish

USFWS captive propagation activities involving paddlefish have taken place at NFHS facilities in a number of states, with an emphasis on restoring particular strains to rivers whose populations are depleted or face possible extirpation. As of FY 2000, multiple USFWS projects were underway in Arkansas, Louisiana, Mississippi, Missouri, Montana, New Mexico, Oklahoma, South Dakota, and Texas; some of the activities were conducted jointly with state wildlife agencies. In addition, several states have carried out independent paddlefish restoration or stocking programs.

Several USFWS facilities have participated in efforts to conserve and restore a paddlefish population in the Red River of Texas and Oklahoma that is thought to face potential extirpation. In FY 2000, Inks Dam NFH in Texas produced 381 Red River strain paddlefish that were taken to Tishomingo NFH in Oklahoma, where they were marked and later released into Lake Texoma-Red River. In another project, Tishomingo NFH released 10,000 paddlefish into the upper reaches of the Red River in an effort to reestablish the population above Denison Dam (Lake Texoma), and provided fry to other hatcheries for rearing. Paddlefish were considered locally extirpated in this stretch of water, and FY 2000 was the second year of propagating paddlefish for the area. Post-stocking sampling indicated that the hatchery-reared fish were doing well in the restoration area (USFWS/FIS 2001).

The Tishomingo FRO has made a concerted effort to assist in recovery efforts for Red River strain paddlefish. With the cooperation of a few knowledgeable anglers, in FY 2000 the FRO located and, with the help of personnel from the Tishomingo NFH, captured several mature paddlefish ready to spawn. These were spawned at Natchitoches NFH in Louisiana, and the progeny were distributed to other hatcheries for rearing. Uvalde NFH in Texas also reared 14,792 Red River strain paddlefish and stocked them into the Red River habitat above Lake Texoma. These fish were the progeny of adults collected by the Tishomingo FRO and spawned at Natchitoches NFH. At Uvalde, fish were raised to 12 inches and tagged using a coded wire inserted in the rostrum prior to release. USFWS estimated tag retention at 88% (USFWS/FIS 2001).

Tishomingo NFH also released 2,000 paddlefish of the Arkansas River strain into Oolagah Lake in an effort to reestablish the population above Oolagah Dam in the Arkansas River drainage. FY 2000 was the seventh year of propagating this population of paddlefish, considered extirpated, for restoration efforts. Post-stocking sampling indicated that the hatchery-reared fish were doing well. Mora NFH and FTC in New Mexico assisted Tishomingo NFH in the development of a water conditioning system to prevent losses caused by high levels of iron in culture water and to provide paddlefish for restoration efforts. Also in FY 2000, Neosho NFH in Missouri contributed to the effort by producing, tagging, and stocking 2,500 10-inch paddlefish as part of the restoration program for the Oolagah Federal Reservoir, as well as shipping over 700,000 eggs and fry to other facilities (USFWS/FIS 2001).

Private John Allen NFH in Mississippi produced 8,300 paddlefish fingerlings in FY 2000 which were provided to the Louisiana Department of Wildlife for stocking in the Mermentau River system in southwest Louisiana. Of these, 3,892 fish were stocked at 10 inches, and the remainder transferred to Mammoth Springs NFH in Arkansas (USFWS/FIS 2001).

Using MICRA guidelines, Mammoth Spring NFH also worked to develop advanced spawning and rearing techniques for paddlefish. Mammoth Spring is responsible for a MICRA paddlefish production commitment for the states of Arkansas, Missouri, and Louisiana, as well as providing additional fish for research. The purpose of the production commitment was to enable stocking in reservoirs linked to tributaries of the Mississippi River. Over the past several years, the hatchery has been so successful in producing paddlefish that it was one of the leading hatcheries for the species. In FY 2000, Mammoth Spring NFH stocked 38,460 12-inch paddlefish in Beaver Reservoir to support paddlefish restoration programs in the lower Mississippi River Basin, raised 5,000 paddlefish for the Mermantau River in Louisiana, and provided 30 sub-adult fish to the Army Corps of Engineers Research Lab for stream flow studies (USFWS/FIS 2001).

Natchitoches NFH in Louisiana spawned Red River stock for the first time in FY 2000, and supplied fry to Mammoth Spring NFH, Private John Allen NFH, and Tishomingo NFH (see above), as well as Booker Fowler State Fish Hatchery (SFH) in Louisiana. FY 2000 activities included distributing 313,509 paddlefish fry to the three NFHs for grow-out, distributing 31,385 advanced paddlefish fingerlings to one NFH and Booker Fowler SFH, and distributing 12,008 10-inch tagged paddlefish (USFWS/FIS 2001).

In recent years, Gavins Point NFH in South Dakota has accomplished spawning, egg incubation, hatching, intensive and extensive rearing, and stocking of paddlefish. Ongoing projects as of FY 2000 included tagging, diet and nutritional studies, disease identification and treatment, monitoring, photographic documentation, skeletal development studies, public awareness and outreach programs, and cooperative research. In FY 2000, 2,702 fingerlings were stocked in the Missouri River, and 150,000 fry were provided to Linesville SFH for Ohio River restoration efforts. An additional 684 fingerlings and 107,568 eggs were provided for research, public outreach, and genetic studies. The Bozeman FHC in Montana monitors captive stock propagated at Gavins Point NFH for regulated fish pathogens before the hatchery conducted any releases. The FHC has also performed monitoring and diagnostics on free-ranging paddlefish in the upper Missouri River Basin (USFWS/FIS 2001).

At the state level, captive propagation or stocking efforts to restore or enhance paddlefish populations have taken place in a number of jurisdictions in the past two decades, often in collaboration with USFWS. Hesse and Carreiro (1997) reported that during the early and mid-1990s, states with stocking programs included Arkansas, Iowa, Louisiana, Missouri, New York, North Dakota, Ohio (1992), Pennsylvania (from 1991 through 1995), South Dakota, Tennessee, and Texas. As reported in their survey, Alabama, Illinois, Indiana, Kentucky, Minnesota, Mississippi, Montana, Nebraska, and Wisconsin did not employ captive propagation or stocking of paddlefish as a management tool during this period, although some of these states may have had programs earlier.

Stocking programs during the survey period were substantial in some states. For example, between 1989 and 1996, 1,027,328 paddlefish were stocked in Texas rivers, including the Trinity River, Neches/Angelina River, Sabine River, Big Cypress Bayou, and Sulphur River (Hesse and Carreiro 1997). When combined with the USFWS efforts to restore the Red River strain of paddlefish in Texas, it would appear that the state's paddlefish restoration program during the 1990s was based largely on stocking. In other states, stocking was far more limited. Hesse and Carreiro reported, for instance, that Ohio stocked paddlefish only in 1992, while Arkansas had a limited stocking program that was considered a secondary priority to habitat restoration.

In late 2002 and early 2003, TRAFFIC conducted a telephone survey of state and provincial fisheries and wildlife agencies in the United States and Canada to inquire about the

status of captive propagation and stocking programs for native Acipenseriformes.[4] The survey found that some U.S. states that had stocked paddlefish prior to or during the 1990s have ceased such activities. Among the states that had reported rearing and stocking paddlefish in the Hesse and Carreiro (1997) survey, TRAFFIC found no stocking currently taking place in Arkansas, Iowa, Missouri, North Dakota, Ohio, Tennessee, and Texas (which discontinued stocking in 2000) (TRAFFIC telephone survey of state fish and wildlife agencies, 2002–2003).

Information provided for TRAFFIC's survey, state responses to the 2000 CITES Significant Trade Review, and data from other sources indicate that captive propagation and/or stocking programs involving paddlefish are ongoing in Louisiana, Kansas, Oklahoma, New York, Pennsylvania, South Dakota, and West Virginia.

Responding to the 2000 CITES Significant Trade Review for paddlefish, Louisiana reported the continuation of its long-term program to propagate paddlefish for restoration purposes, in cooperation with USFWS. State propagation efforts have been centered at the Booker Fowler SFH in Woodworth, Louisiana, with fish produced being reintroduced into portions of their range where they are no longer found, or where population declines are evident (J. Roussel, Assistant Secretary, Office of Fisheries, Louisiana Department of Wildlife and Fisheries, *in litt*. to Teiko Saito, USFWS/OMA, August 25, 2000). As of 2002, the state reported the production of some 50,000 to 100,000 paddlefish per year (pers. comm., B. Reed, Louisiana Department of Wildlife and Fisheries, September 2002). The Louisiana Inland Fish Division has also participated actively in a large-scale, basin-wide tagging study being undertaken under the auspices of MICRA (J. Roussel, Assistant Secretary, Office of Fisheries, Louisiana Department of Wildlife and Fisheries, *in litt*. to Teiko Saito, USFWS/OMA, August 25, 2000).

Kansas reported rearing paddlefish for restoration purposes at the Milford Fish Hatchery in Junction City, Kansas during the years 1992 to 2000, with broodstock obtained from Missouri and Oklahoma. State policy required that the fish be obtained from the nearest existing stock for restoration, and all stocked fish had to have coded wire tags following procedures established by the MICRA paddlefish/sturgeon subcommittee. The state reported that the Arkansas River population is the result of stocking efforts in Kaw River, Oklahoma, by the Kansas Department of Wildlife and Parks (KDWP) and the Oklahoma Department of Wildlife Conservation; some of the fish reared at the Milford Hatchery originated from broodstock collected at Grand Lake, Oklahoma (T. Mosher, Fisheries Research Coordinator, KDWP, *in litt*. to Teiko Saito, USFWS/OMA, August 17, 2000).

The state also has two paddlefish population segments in the Kansas River. The population below the Bowersock Dam at Lawrence, Kansas is a combination of naturally occurring fish from the Missouri River and stocked fish that escaped from Turtle Creek Reservoir. The brood source for these fish was the Blind Pony Hatchery operated by the Missouri Department of Conservation; young were reared at the Milford Hatchery in Kansas. Similarly, the Marais des Cygnes population resulted from spawning runs from Truman Reservoir, Missouri. Where once this population reproduced naturally, today it is maintained primarily through stocking by the Missouri Department of Conservation. In most years, movement is blocked by the Osawotomie Dam, but paddlefish have been recorded upstream during high flood years. The state's Neosho River population, like that in the Kansas River, can also be divided into two segments. In 1995 and 2000, the KDWP stocked paddlefish into the John Redmond Reservoir, where limited reproduction has been recorded. The broodstock for these paddlefish came from Grand Lake, Oklahoma and were raised at the Milford Hatchery. There is also a second population that migrates from Grand Lake into the lower Neosho River, where the snag fishery summarized in Section IV takes place (T. Mosher, Fisheries Research Coordinator, KDWP, *in litt*. to Teiko Saito, USFWS/OMA, August 17, 2000).

[4] U.S. states and Canadian provinces surveyed by TRAFFIC are listed at the end of the References section of this report.

Table 6.1.2 summarizes paddlefish stocking by the KDWP in Kansas and Oklahoma from 1992 through 2000. Kansas has not stocked paddlefish since 2000. The state has continued to try to rear fish at the Milford Hatchery, but has had poor survival rates of eggs and young during the past few years (pers. comm., T. Mosher, KDWP, September, 2002).

Oklahoma also reported use of captive propagation and stocking of paddlefish as an essential conservation and management tool. As noted above, Oklahoma is working with both the federal government and neighboring states such as Kansas to reintroduce native paddlefish strains back into portions of their range where they have been extirpated or are rare. Table 6.1.3 summarizes recent reintroduction efforts in Oklahoma.

Both New York and Pennsylvania have employed captive propagation and stocking to restore paddlefish populations to waters in which the species has been considered extirpated. In New York, where the species was believed extirpated by the early 1900s, a restoration program based on stocking of paddlefish fingerlings was initiated in 1998. A total of 713 paddlefish were stocked in New York between 1998 and 2000, and in 2001 the state reported stocking 1,878 paddlefish in Kinzua Reservoir. Stocking was expected to continue at least through 2002 (Henley et al. in press; NYS/DEC 2002a). If there turns out to be a meaningful rate of survival of the stocked fish, the state anticipates taking measures to prohibit harvest of the species (Patrick Festa, Inland Fisheries Management Section,

Table 6.1.2 Paddlefish Stocking by Kansas Department of Wildlife and Parks in Kansas and Oklahoma, 1992–2000*

Location	Year	Number	Source
Arkansas River, OK	1992	10,150	Blind Pony, MO
Arkansas River, OK	1992	7,850	Tishimingo National Fish Hatchery
Turtle Creek Reservoir	1992	4,267	Blind Pony, MO
Arkansas River, OK	1993	681	Gavins Pt. National Fish Hatchery
Arkansas River, OK	1993	11,004	Blind Pony, MO
Arkansas River, OK	1994	10,458	Tishimingo National Fish Hatchery
Turtle Creek Reservoir	1994	6,460	Blind Pony, MO
Turtle Creek Reservoir	1995	5,470	Blind Pony, MO
John Redmond Reservoir	1995	726	Blind Pony, MO
John Redmond Reservoir	2000	7,100	Grand Lake, OK

* Source: T. Mosher, Fisheries Research Coordinator, KDWP, *in litt.* to Teiko Saito, USFWS/OMA, August 17, 2000.

Table 6.1.3 Oklahoma Reservoirs with Paddlefish Reintroduced*

	Number of Paddlefish Reintroduced by Reservoir		
Year	Kaw Reservoir	Oologah Reservoir	Texhoma Reservoir
1992	18,890	—	—
1993	25,185	—	—
1994	16,750	—	—
1995	2,013	5,974	—
1996	—	112	—
1997	—	10,719	—
1998	—	2,037	—
1999	—	8,837	5,757
2000	—	3,450	20,846

* Source: Kim E. Erickson, Chief, Fisheries Division, Oklahoma Department of Wildlife Conservation, *in litt.* to Teiko Saito, USFWS/OMA, August 28, 2000.

Department of Environmental Conservation, *in litt*. to Teiko Saito USFWS/OMA, August 22, 2000). Experimental culture of paddlefish is underway at the Oneida SFH in Oswego County (NYS/DEC 2002b).

Pennsylvania, which reported the last documentation of native paddlefish in 1919, has continued a long-term restoration program for paddlefish in the major rivers of western Pennsylvania, primarily the Allegheny and Ohio Rivers. Begun in 1991, the program has received paddlefish fry from the Gavins Point NFH in South Dakota. The fish are grown out at the Linesville Fish Culture Station, tagged with coded wire, and released. Between 1991 and 2001, the Pennsylvania Fish and Boat Commission stocked 70,417 paddlefish in the upper reaches of the Ohio and Allegheny rivers (Parr 1999; Henley et al. in press). The effort has centered on establishing a spawning population and then managing it on a self-sustaining basis. Given the number of years that the program has been underway, it is possible that individuals have reached sexual maturity (Richard Snyder, Chief, Division of Fisheries Management, Pennsylvania Fish and Boat Commission, *in litt*. to Teiko Saito, USFWS/OMA, August 15, 2000).

South Dakota has undertaken an active, long-term stocking program in the Missouri River system. As shown in Table 6.1.4, between 1985 and 1992 the state regularly stocked fingerlings and fry in several water bodies. Since 1993, South Dakota stockings have concentrated on the release of fingerlings into the Francis Case Reservoir.

Table 6.1.4 South Dakota Paddlefish Stockings, 1985–2002*

Year	Water	Body Size	Number Stocked
1985	Francis Case	Fingerling	27,316
	White River	Fingerling	24,000
1986	Francis Case	Fingerling	39,845
	White River	Fingerling	12,350
	Ft. Randall Tailwaters	Fingerling	5,000
1987	Lewis and Clark	Fingerling	8,500
1988	Francis Case	Fry	400,000
	White River	Fry	680,000
	Lewis and Clark	Fingerling	22,212
1989	Lewis and Clark	Fingerling	19,980
	Ft. Randall Tailwaters	Fingerling	20,000
1990	Francis Case	Fry	180,000
	Francis Case	Fingerling	3,418
	Ft. Randall Tailwaters	Fingerling	17,257
1991	Francis Case	Fingerling	49,460
	Lewis and Clark	Fingerling	24,690
1992	Francis Case	Fingerling	20,218
	Ft. Randall Tailwaters	Fingerling	17,980
	Lewis and Clark Fingerling	Fingerling	3,439
1993	Francis Case	Fingerling	23,310
1994	Francis Case	Fingerling	21,394
1995	Francis Case	Fingerling	28,934
1996	Francis Case	Fingerling	11,731
1997	Francis Case	Fingerling	13,810
1998	Francis Case	Fingerling	13,271
1999	Francis Case	Fingerling	32,646
2000	Francis Case	Fingerling	2,702
2001	Francis Case	Fingerling	538
2002	Francis Case	Fingerling	1,597

* Source: C. Stone, South Dakota Department of Game, Fish and Parks, *in litt.* to TRAFFIC North America, January 2003.

West Virginia began stocking paddlefish in 1992 as a component of recovery efforts for the species, which is considered rare in the state. The West Virginia Division of Natural Resources has conducted these stockings with the goal of restoring paddlefish to levels that will permit sport fishing (Henley et al. in press). In recent years paddlefish have been released in the Ohio, Kanawha, and Monongahela rivers. In 2000 and 2001, paddlefish stocking concentrated in the Ohio River (309 paddlefish in 2000; 267 paddlefish in 2001). In 2002, 4,386 paddlefish were stocked by the state, including 2,171 in the Ohio River, 2,009 in the Kanawha River, and 206 in the Monongahela River (pers. comm., C. O'Bara, West Virginia Division of Natural Resources, January 2003).

Shovelnose Sturgeon

Captive propagation of shovelnose sturgeon has not been a priority for the USFWS Fisheries Program. USFWS interest in shovelnose sturgeon has primarily involved their use as a surrogate for pallid sturgeon in research on iridoviruses, in the development of culture techniques, and in studies on the genetic distinction and hybridization of sturgeon species of the genus *Scaphirhynchus* (USFWS 2000h; USFWS/FIS 2001).

Shovelnose sturgeon have, however, been propagated at Gavins Point NFH, Natchitoches NFH, and Garrison Dam NFH. Hesse and Carreiro (1997) reported that the Gavins Point NFH broodstock originated in the Missouri River reach between Lewis and Clark Lake and the Yellowstone River; the Natchitoches NFH broodstock came from the Old River Control Complex (ORCC) in Louisiana; and the Garrison Dam NFH broodstock came from the Missouri and Yellowstone Rivers.

One state with an active stocking program has been Wyoming, where efforts have concentrated within the Big Horn Basin. Figures provided by the Wyoming Department of Game and Fish show the cumulative stocking of 375,000 fry between 1996 and 1998; 10,177 fingerlings in 1997 and 1998; and 3,384 juveniles from 1996 to 1998. In 2002 the state stocked 1,300 juveniles in the Big Horn River. Normal stocking has occurred either in the Big Horn River from Worland to Big Horn Lake or in the Nowood River several miles up from the confluence with the Big Horn River (pers. comm., S. Yekel, Wyoming Department of Game and Fish, January 2003). Hesse and Carreiro (1997) also reported the stocking of fry from the Garrison Dam NFH into the Powder River in the 1990s. Shovelnose sturgeon produced from Yellowstone River broodstock and reared at Gavins Point NFH that were stocked into the Big Horn River in 1998 were reported to be doing well based on growth rates and recaptures that suggested a wide distribution (USFWS 2000h). Wyoming will continue to stock shovelnose sturgeon as part of a five to seven year program, subject to the availability of fish from hatcheries (pers. comm., S. Yekel, Wyoming Department of Game and Fish, January 2003).

West Virginia began stocking shovelnose sturgeon in 2002, when 40 fish were released in the Kanawha River. The source of the broodstock was the Wabash River. The state anticipates continuing to stock shovelnose sturgeon in future years (pers. comm., C. O'Bara, West Virginia Division of Natural Resources, January 2003).

Ohio is also propagating shovelnose sturgeon, which are listed as a state endangered species, for reintroduction purposes (pers. comm., R. Sanders, Ohio Department of Natural Resources, September 2002).

Alabama Sturgeon

One of the stated goals of the Conservation Agreement for the Alabama Sturgeon (Scaphirynchus suttkusi), signed in February 2000 (see Section IV of this report for details) was to restore and maintain sufficient numbers of Alabama sturgeon in the lower Alabama River so as to ensure its long-term survival, by increasing the number of sturgeon through hatchery propagation and augmentation (Anon. 2000b). The agreement recognized that the species' depressed population size and an apparent inability to offset mortality rates with natural reproduction, likely caused by the destruction or modification of its habitat, posed a grave threat to the Alabama sturgeon's survival.

As part of the recovery strategy for the Alabama sturgeon, federal, state, and

nongovernmental partners agreed to work cooperatively to collect broodstock and implement a hatchery program to produce young that can be stocked throughout their historic range. Partners in the effort included USFWS, the Alabama Department of Conservation and Natural Resources (ADCNR) Division of Wildlife and Freshwater Fisheries, the U.S. Army Corps of Engineers, the Alabama-Tombigbee Rivers Coalition, and others (Anon. 2000b).

Ongoing work at Warm Springs NFH in Georgia to improve and refine spawning and culture techniques for paddlefish and sturgeon species, including the Alabama sturgeon, has been part of the recovery effort (USFWS/FIS 2001). Since 1997, ADCNR has coordinated an intensive effort to collect broodstock, which resulted in the capture of four Alabama sturgeon for captive propagation purposes from the late 1990s to 2001 (Anon. 1999a, 2000b; Moss 2001). Fish collected have been held at the Marion SFH, which was modified to maintain and propagate Alabama sturgeon. A mature male and female sturgeon collected during 1997 were induced to spawn in March 1999. The female produced more than 4,000 eggs, but the male failed to produce sperm and the fertilization attempt was unsuccessful. The captive female died in April 1999, and as of 2000 two males remained in captivity (Anon. 2000b). Collection and captive propagation efforts continue to be central to the species' recovery strategy.

Pallid Sturgeon

Until recently, there was no confirmed reproduction in remnant wild pallid sturgeon populations. The first-ever reported capture of a young-of-the-year pallid sturgeon did not occur until July 1998 in the Mississippi River south of Cape Girardeau, Missouri (USFWS 1999b). In 1998 and 1999, a total of three larval pallid sturgeon were collected in the lower Missouri River; this was the first documented evidence of natural reproduction in that river section (USFWS 2000h). Given the scant evidence of wild reproduction, species research and captive propagation have been considered essential to the continued existence of the species.

The first successful hatchery rearing of pallid sturgeon progeny occurred in 1992. The 1993 USFWS Pallid Sturgeon Recovery Plan explicitly endorsed captive propagation as a recovery tool. The plan called for the development of a pallid sturgeon propagation and stocking program; a tagging protocol for stocked fish; and the provision of financial resources to hatcheries for structural modifications, operations, and maintenance. It also called for research into methods to improve spawning, culture, and rearing of pallid sturgeon in hatcheries, as well as conducting reintroduction/augmentation programs in accordance with a stocking plan approved by federal and state authorities. As with other sturgeon species, the plan emphasized that "maintenance of genetic fitness must not be compromised through stocking efforts." These steps were part of an overall short-term recovery objective to prevent species extinction by establishing at least three captive broodstock populations in separate hatcheries by 1998 (USFWS 1993).

USFWS, in conjunction with state wildlife agencies and other partners, has actively engaged in pallid sturgeon captive propagation and stocking efforts since the publication of the recovery plan. The primary NFHs involved in the captive rearing of pallid sturgeon have been Natchitoches in Louisiana, Gavins Point in South Dakota, and Garrison Dam in North Dakota. Missouri's Blind Pony SFH has also been actively involved in rearing and stocking captive-propagated pallid sturgeon (USFWS 1999b, 2000h, 2002e).

States that have stocked pallid sturgeon as part of research and recovery efforts include Louisiana, Missouri, Montana, Nebraska, North Dakota, and South Dakota. For example, approximately 7,000 pallid sturgeon fingerlings reared at Blind Pony hatchery in 1992 were stocked into the Missouri and Mississippi rivers in 1994. An additional 3,000 pallid sturgeon from the same hatchery were stocked into the same rivers in 1997. In 1997 and 1998, hatchery- reared pallid sturgeon were also released into the Platte River in Nebraska, the Missouri River above Fort Peck Reservoir, the Lower Yellowstone River and the Missouri River between Lake Sakakawea and Fort Peck Dam, and the Lower Mississippi River near the

ORCC in Concordia Parish, Louisiana (USFWS 1999b, 2000h, 2002e).

While reintroduction and augmentation projects continued into 1999 and 2000, the discovery of an iridovirus in shovelnose sturgeon at the Gavins Point NFH and pallid sturgeon at the Garrison Dam NFH in those years created serious concerns and hampered the recovery effort. Both the 1999 and 2000 year-classes of pallid sturgeon spawned and cultured at the Garrison Dam NFH were destroyed in the spring of 2001 because of the virus. Fortunately, pallid sturgeon spawned at the Gavins Point NFH during these years did not experience any disease problems, which allowed limited stocking to continue in the Lower Missouri and Yellowstone rivers in 2000 (USFWS 2000h, 2002e). However, the discovery of the iridovirus points to the need for caution and careful monitoring of captive propagation and stocking efforts.

Lake Sturgeon

Similar to paddlefish, captive propagation and stocking of lake sturgeon has been employed as a management or recovery tool by some U.S. states within the species' range, but not all. Michigan, Minnesota, Missouri, New York, Tennessee, and Wisconsin have been particularly active in captive propagation efforts or stocking programs. In Ohio, some lake sturgeon are being reared at Ohio State University, but these fish are not being released because they are not from the same strain as native stocks (pers. comm., R. Sanders, Ohio Department of Natural Resources, September 2002).

Michigan produces lake sturgeon only at the Wolf Lake Fish Hatchery in Mattawan, Michigan. All eggs in the state's program are obtained from wild stocks that are considered to be in good condition from a population perspective. Since 1995, the Michigan Department of Natural Resources (DNR) has been working to determine the genetic stock structure of Michigan's lake sturgeon populations, and this has been largely completed with the assistance of Michigan State University. Currently, only fish from appropriate genetic stocks are planted in Michigan waters (pers. comm., G. Whelan, Fish Production Manager, Michigan DNR, February 2003).

During the period 1990 to 2001, the state's fish stocking database recorded 23 releases, totaling 79,407 lake sturgeon, into 10 Michigan water bodies in nine counties. According to the database, releases occurred from 1990 through 1995, and then again from 1998 through 2001. The size of the fish released varied, ranging from an average of 2.68 inches (5,137 fish released in Mullett Lake in 1990) to 15.8 inches (12 fish released into the Ontonagon River in 2001). Information from the database, supplemented by further data provided by the Michigan DNR, also show the strains of lake sturgeon released since 1994, which included Black Lake–Cheboygan County, Menominee River–Menominee County, Sturgeon River–Baraga County, and the St. Clair River–St. Clair County (Michigan DNR 2002; pers. comm., G. Whelan, Fish Production Manager, Michigan DNR, February 2003). Table 6.1.5 shows Michigan stockings of lake sturgeon during the years 1990–2001.

Minnesota has been involved in a cooperative program to restock the St. Louis River near Duluth. The broodstock came from a Michigan source connected to Lake Superior. Restocking efforts have also involved transferring juvenile lake sturgeon from the Rainy River to the Otter Tail River and Big Detroit Lake in Minnesota (Linda Erickson-Eastwood, Fisheries Program Manager, Minnesota Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 23, 2000). In 1998, the state of Minnesota stocked 25 adult lake sturgeon into Big Detroit Lake and 172 adults into the Otter Tail River (Minnesota DNR 2002).

In the late 1990s, USFWS and the White Earth Indian Reservation also worked with First Nations partners in Ontario to restock White Earth and Round Lakes in Minnesota with fingerling lake sturgeon. The source of the fish was the Canadian waters of the Rainy River (Linda Erickson-Eastwood, Fisheries Program Manager, Minnesota Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 23, 2000).

Records provided by Missouri reported the stocking of approximately 164,000 lake sturgeon in the Mississippi and Missouri rivers between 1984 and 2000. According to a lake

Table 6.1.5 Michigan Stocking of Lake Sturgeon, 1990–2001*

Year	County	Water Body	Strain	Number	Average Length
1990	Cheboygan	Mullett Lake	N/A	5,137	2.68
	Cheboygan	Burt Lake	N/A	5,010	3.36
	Luce	Big Manastique Lake	N/A	6,898	3.40
1991	Delta	Lake Michigan	N/A	4	10.60
	Otsego	Otsego Lake	N/A	7,062	2.72
1992	Otsego	Otsego Lake	N/A	2,751	5.44
1993	Luce	Big Manastique Lake	N/A	7,636	4.24
	Otsego	Otsego Lake	N/A	1,998	3.96
	Otsego	Otsego Lake	N/A	1,998	4.96
1994	Dickinson	Menominee River	Menominee River	12	11.72
	Dickinson	Menominee River	Menominee River	412	7.12
1995	Dickinson	Menominee River	Menominee River	478	5.60
	Dickinson	Menominee River	Menominee River	4,494	7.64
	Dickinson	Menominee River	Menominee River	9,900	6.08
1996	—	—	—	—	—
1997	—	—	—	—	—
1998	Baraga	Sturgeon River	Sturgeon River	700	4.76
	Ontonagon	Ontonagon River	Sturgeon River	6,065	4.76
1999	Menominee	Menominee River	Menominee River	591	12.72
	Ontonagon	Ontonagon River	Sturgeon River	2,820	5.32
	St. Clair	St. Clair River	St. Clair River	3,565	5.32
2000	Ontonagon	Ontonagon River	Sturgeon River	7,518	8.00
2001	Cheboygan	Black River	Black Lake	890	5.80
	Ontonagon	Ontonagon River	Sturgeon River	12	15.80
	Ontonagon	Ontonagon River	Sturgeon River	3,456	8.48

Key: N/A = Not available.

* Source: Michigan DNR (2002); pers. comm., G. Whelan, Fish Production Manager, Michigan DNR, February 2003.

sturgeon stocking history provided by the Missouri Department of Conservation, stockings of lake sturgeon over six inches long took place in 1984 (12,279 fish), 1985 (373 fish), 1986 (10,763 fish), 1988 (9,503 fish), 1989 (47 fish), 1990 (11,000 fish), 1991 (15,103 fish), 1992 (11,036 fish), 1993 (8,514 fish), 1994 (21,088 fish), 1995 (35,164 fish), and 1996 (9,012 fish). In addition, the stocking history showed stockings of lake sturgeon under six inches in 1984, 1985, 1992, 1993, and 1995. The predominant source of these fish appeared to be lake sturgeon eggs provided regularly to the Blind Pony SFH by the Wisconsin Department of Natural Resources (Kim Graham, Missouri Department of Conservation, *in litt*. USFWS/OMA, August 2000; USFWS 2000h).

The New York Department of Environmental Conservation has worked with USFWS and others to use captive propagation of lake sturgeon to reestablish populations in selected tributaries of Lake Ontario and the St. Lawrence River, including the Oswegatchie River, Black Lake, the St. Regis River, Oneida Lake, and Cayuga Lake. Survival rates among released lake sturgeon has been reported as high, and populations are believed to be building. Lake sturgeon eggs for this program are collected from wild stocks in the St. Lawrence River. The state does not maintain a captive broodstock, although some experimental culture of lake sturgeon has been conducted at the Oneida SFH in Oswego County (NYS/DEC 1999, 2002a; Patrick Festa, Inland Fisheries Management Section, Department of Environmental Conservation, *in litt*. to Teiko Saito USFWS/OMA, August 22, 2000).

Pittsford NFH in Vermont has participated in New York's effort by rearing St. Lawrence River strain lake sturgeon for the restoration program in the St. Lawrence River and its tributaries in the state of New York. These fish have not been released in Vermont waters (Chet MacKenzie, Vermont Department of Fish and Wildlife, *in litt*. to Teiko Saito,

USFWS/OMA, August 30, 2000). Pittsford NFH has also investigated new lake sturgeon culture techniques and starter diet success with lake sturgeon fry (USFWS/FIS 2001).

Tennessee's lake sturgeon restoration project, which has been based on captive propagation, is an example of broad-based public-private collaboration. The Tennessee Aquarium and its research unit, SARI, are cooperating with USFWS, the World Wildlife Fund, the Tennessee Valley Authority (TVA), the Tennessee Wildlife Resources Agency (TWRA), the U.S. Geological Survey (USGS), and the Wisconsin Department of Natural Resources in an effort to reintroduce lake sturgeon to a portion of its native habitat in northeastern Tennessee.

It is believed that lake sturgeon were once common in the Tennessee River system [Etnier and Starnes (1993), cited by Benz (2001)], with location records as far upriver as the North Carolina portion of the French Broad River. Since the mid-1900s, there are only a handful of lake sturgeon records from the Tennessee River system, and most specimens seen during the last decade probably represent some of the Wisconsin-origin eggs that were hatched and subsequently released (over 3,850 individuals) into the Clinch River above Norris Reservoir by the Tennessee Valley Authority (TVA) in 1992 (pers. comm., C. Saylor, TVA, cited by Benz 2001).

In recent years, a number of favorable conditions have made it possible to consider reestablishing lake sturgeon in the upper Tennessee River system. For example, fishing is now more tightly regulated, water quality within the Tennessee River has improved throughout the past few decades, and there is an appropriate stock of lake sturgeon available to drive reintroduction efforts. Also, governmental and non-governmental agencies and organizations dedicated program resources for a reintroduction project (Benz 2001).

A 1998 pilot project marked the beginning of a long-term lake sturgeon reintroduction program with a primary objective of establishing a self-sustaining population of lake sturgeon within the upper Tennessee River system. The decision to use Wisconsin-origin lake sturgeon for reintroduction purposes in this system was based on factors related to availability, genetic representation within the upper Tennessee River system, and the lack of availability of lake sturgeon from closer waters (Benz 2001).

During the years 1998 through 2001, sturgeon eggs obtained from Wisconsin were hatched and reared in spring-fed raceways at the SARI facility in Cohutta, Georgia. The program's first sizable fish releases took place during the summer of 2000, when 1,200 one-year-old lake sturgeon were stocked into the French Broad River. All fish were marked with internal wire tags. As of 2001, no sightings of dead sturgeon were reported from the stretch of river where the fish were released, and two tagged sturgeon were captured during limited sampling aimed at documenting the survival of this cohort (Benz 2001).

During 1999 and 2000, several dozen juvenile sturgeon were also implanted with radio tags and released into the French Broad River to begin gathering information regarding survival and habitat use. In FY 2000, Warm Springs NFH participated by providing 24 lake sturgeon to Tennessee Technological University and SARI for this biotelemetry study in the lower French Broad River, Tennessee (USFWS/FIS 2001). These studies have indicated high survival rates of tagged fish. The sturgeon also appear capable of utilizing a lengthy stretch of habitat within the upper Tennessee River system (Benz 2001).

In Wisconsin, the White Rose hatchery propagates several lots of sturgeon from different water bodies for restoration purposes. Under state regulations, fish can only be stocked into the same basin—no inter-basin transfers are allowed in the state. However, as previously summarized, lake sturgeon from Wisconsin are used in restocking programs in other states such as Missouri and Tennessee (Benz 2001). Along with the state hatchery, in FY 2000, Neosho NFH produced, tagged, and stocked 3,000 six-inch lake sturgeon as part of a restoration effort for Legend Lake on the Menominee Indian Nation Reservation in Wisconsin. This was a cooperative effort with the Genoa NFH and the LaCrosse FRO in Wisconsin. Genoa NFH also produced about 5,000 lake sturgeon of the Wolf River strain and released them in waters on Menominee Indian Nation lands, transferred 15,000 lake

sturgeon fry to Neosho NFH for use in that facility's propagation program, and transferred 25,000 lake sturgeon eggs to the Upper Midwest Environmental Science Center in LaCrosse, Wisconsin (USFWS/FIS 2001).

In Canada, TRAFFIC's 2002–2003 telephone survey of fish culture specialists and hatchery managers in provinces within the range of the lake sturgeon found limited captive propagation and stocking. TRAFFIC's survey found no captive propagation or stocking of lake sturgeon currently underway in Alberta, Ontario, or Quebec. In recent years Saskatchewan has conducted some limited stocking of lake sturgeon in the Cumberland Delta area of the Saskatchewan River system, including 32,900 fry stocked in 1999, and 300 fingerlings and 22,000 fry stocked in 2000. To date, the fish have come from hatcheries in Manitoba, but the province plans on beginning a program to rear lake sturgeon in the summer of 2003 (pers. comm., J. Banks, Saskatchewan Department of Environment, January 2003). Manitoba reported some limited captive propagation and stocking in northern provincial waters, often in conjunction with educational efforts and a component emphasizing the traditional cultural value of lake sturgeon (pers. comm., B. Scaife, Manitoba Conservation, February 2003).

White Sturgeon

In FY 2000, Abernathy National Salmon Technical Center in Washington caught wild adult Columbia River sturgeon for use as broodstock. The adults were released after spawning. Fish produced from this effort will be used to restore declining Columbia River populations. In FY 2000, the Idaho FHC successfully spawned 5 female and 11 male Kootenai River white sturgeon, and assisted in the release of eight family groups to promote recovery efforts (USFWS/FIS 2001).

Several cooperative initiatives have also been conducted with public and private partners to promote recovery of the Kootenai River population of white sturgeon. The primary activities have taken place in Idaho and British Columbia, where the Idaho Department of Fish and Game, the B.C. Ministry of Environment, the B.C. Ministry of Fisheries, and the Kootenai Tribe, together with federal authorities, are collaborating on the propagation and stocking of white sturgeon in the Kootenai River. As seen in Section 5.3 of this report under Legal Trade, in 1999 the Kootenai Tribe exported some 80,000 fertilized eggs to British Columbia management authorities who are involved in a cooperative captive propagation and recovery program with U.S. management authorities.

The Idaho FHC is also a cooperating partner in a program funded by the Bonneville Power Administration to prevent extinction, preserve remaining genetic variability, and rebuild the natural age class structure of the Kootenai River white sturgeon population. Idaho FHC is working with the Kootenai Tribe of Idaho to collect samples from spawning adult sturgeon, as well as monitoring and pre-release samples on juvenile sturgeon. Idaho FHC played a significant role in the release of brood-year (BY) 1995 juveniles (the first release) and the transfer of half of the BY 1999 eggs to a back-up hatchery in Canada to protect against catastrophic losses. Idaho FHC also extensively sampled wild fish in the Kootenai River drainage in addition to the captive fish to satisfy Canadian concerns and requirements for the safe release and transfer of sturgeon (Idaho FHC 2001).

The involvement of provincial authorities in British Columbia in captive propagation of white sturgeon has been a fairly recent development. Traditionally, the primary role of the provincial Fish Culture Section was production of salmonid species for recreational fisheries. However, there are now two projects underway to support species recovery for the white sturgeon: the Kootenay River Sturgeon Conservation Hatchery and the Columbia River Sturgeon Conservation Hatchery. In addition, the Nechako River White Sturgeon Recovery initiative is considering a conservation fish culture component to assist in recovery efforts (B.C. Fisheries 2001b).

6.2 Commercial Aquaculture

Based upon information reported for CITES Significant Trade Reviews of various North American paddlefish and sturgeon species, TRAFFIC's 2002–2003 telephone survey of state and provincial wildlife and fisheries agencies in the United States and Canada, and

other sources, TRAFFIC has found that commercial aquaculture ventures involving North American Acipenseriformes are concentrated primarily in the United States. Commercial operations in a few states in the Mississippi Basin focus mostly on paddlefish. There is also believed to be some activity involving lake sturgeon in Minnesota, and possibly shovelnose sturgeon in Illinois. Other operations, principally in California, rear white sturgeon. In 2001, the ASMFC for the first time approved an application to begin a commercial aquaculture operation involving Atlantic sturgeon in Florida. TRAFFIC found no commercial aquaculture underway for Gulf, shortnose, Alabama, pallid, or green sturgeon.

Commercial aquaculture of Acipenseriformes is less common in Canada. There is some commercial aquaculture involving Atlantic sturgeon in the Maritime provinces, and interest has been growing regarding commercial aquaculture for white sturgeon in British Columbia. There are also commercial operations licensed to rear lake sturgeon in Ontario, as well as some aquaculture that has been conducted there by First Nations tribes.

Table 6.2.1 summarizes commercial aquaculture of paddlefish, lake sturgeon, white sturgeon, and Atlantic sturgeon in the United States and Canada. It should be noted as an important caveat that the table records a "yes" for the presence of commercial aquaculture in states and provinces that have licensed operations for the indicated species. As is explained in more detail in the species summaries that follow, it is not clear that all such jurisdictions actually have commercial operations that are actively rearing the species in question.

Atlantic Sturgeon

As of 2001, the only source of commercially reared Atlantic sturgeon was in the Canadian province of New Brunswick. As noted in Section V on Legal and Illegal Trade, live specimens have been exported in recent years.

In the United States, in 2001 the ASMFC approved an exemption to allow the importation of non-indigenous Atlantic sturgeon fingerlings from Canada into the state of Florida. The sale of live fingerlings, cultured from eggs taken from wild Atlantic sturgeon broodfish populations in the Saint John River system in New Brunswick, will involve a joint initiative between the Canadian Sturgeon Conservation Centre (previously known as the Canadian Caviar Company), academic researchers, and several private aquaculturalists. Production of Atlantic sturgeon as domestic foodfish and caviar for the United States is the primary intent. International sales are an option, so long as such transactions are accompanied by CITES permits for export (ASMFC 2001c; Anon. 2001a).

Paddlefish

In response to the 2000 CITES Significant Trade Review inquiry for paddlefish, the majority of states within and outside of the present range of the species reported that they had no private or commercial aquaculture of paddlefish as of that year. Outside of the species' range, negative responses came from Connecticut, Delaware, Florida, Idaho, Maryland, Michigan, New Hampshire, South Carolina, Utah, Virginia, and Wyoming. Arizona indicated that, although the state lies outside of the native range of North American Acipenseriformes, there had been instances of paddlefish aquaculture in the past half century. The state was unaware of any present occurrences (L. Riley, Chief of Fisheries, Arizona Department of Game and Fish, *in litt*. to Teiko Saito, USFWS/OMA, August 25, 2000). Georgia reported that a private aquaculturalist was holding a few adults for experimental breeding purposes, but had produced no paddlefish for sale or trade (R. Gennings, Chief of Fisheries, Georgia Department of Natural Resources, Wildlife Division, *in litt*. to Teiko Saito, USFWS/OMA, August 21, 2000). Hawaii reported some experimental culture of unspecified "sturgeon" species (M. Fujimoto, Acting Administrator, Hawaii Department of Land and Natural Resources Division of Aquatic Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 14, 2000). The remainder of U.S. states outside of the paddlefish's range did not respond to the Significant Trade Review inquiry.

Within the range of the paddlefish, Arkansas, Louisiana, Minnesota, Montana, Oklahoma,

Table 6.2.1 Summary of Commercial Aquaculture for Paddlefish and sturgeon Species in the United States and Canada, 2002*

State	Paddlefish	Lake sturgeon	White Sturgeon	Atlantic Sturgeon
Alabama	No	No	No	No
Arkansas	No	No	No	No
California	No	No	Yes	No
Florida	No	No	No	Yes
Georgia	Yes	No	No	No
Idaho	No	No	Yes	No
Illinois	Yes	No	No	No
Indiana	No	No	No	No
Iowa	No	No	No	No
Kansas	No	No	No	No
Kentucky	Yes	No	No	No
Louisiana	No	No	No	No
Michigan	No	No	No	No
Minnesota	No	Yes	No	No
Mississippi	No	No	No	No
Missouri	Yes	No	No	No
Montana	No	No	No	No
Nebraska	No	No	Yes	No
New York	No	No	No	No
North Dakota	No	No	No	No
Ohio	Yes	No	No	No
Oklahoma	No	No	No	No
Oregon	No	No	Yes	No
Pennsylvania	No	No	No	No
South Dakota	No	No	No	No
Tennessee	Yes	No	No	No
Vermont	No	No	No	No
Washington	No	No	No	No
West Virginia	No	No	No	No
Wisconsin	No	No	No	No
Alberta	No	No	No	No
Brit. Columbia	No	No	Yes	No
Manitoba	No	No	No	No
New Brunswick	No	No	No	Yes
Nova Scotia	No	No	No	No
Ontario	No	Yes	No	No
PEI	No	No	No	No
Quebec	No	No	No	No
Saskatchewan	No	No	No	No

* Compiled by TRAFFIC North America from various literature, *in litt.* correspondence, and personal communications. More details and specific references are included in the species summaries below.

Tennessee, and Wisconsin reported no private or commercial aquaculture as of 2000. Kansas, New York, Ohio, Pennsylvania, and South Dakota reported that those states were not aware of any such efforts. North Dakota reported that the state prohibits commercial paddlefish aquaculture. Illinois, Kentucky, and Missouri indicated that there was ongoing commercial aquaculture of paddlefish. Information on the subject was not provided in

the responses of state authorities from Alabama, Iowa, Mississippi, and Nebraska. Indiana and West Virginia did not respond to the CITES inquiry.

Among states that reported commercial paddlefish aquaculture for the 2000 Significant Trade Review, Illinois noted that while the paddlefish was an approved aquaculture species, the amount of aquaculture activity involving the species was insignificant and could best be described as a few experimental growers (Mike Conlin, Chief, Division of Fisheries, Illinois Department of Natural Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 23, 2000). Missouri had four registered commercial aquaculture operations that reported having paddlefish as of 1998 (Missouri Department of Conservation 1998). The state with the greatest number of reported commercial paddlefish aquaculture facilities in 2000 was Kentucky, which reported six commercial propagators for the CITES Significant Trade Review (P. Pfeiffer, Director, Division of Fisheries, Kentucky Department of Fish and Wildlife Resources, *in litt*. to Teiko Saito, USFWS/OMA, August 16, 2000). None of these facilities, however, were reported to have reached a point where they were producing caviar for the market.

In 2002 and early 2003, TRAFFIC surveyed state fisheries agencies within the present or historic range of the paddlefish by telephone to update the information previously provided, and to determine whether the situation had changed significantly. TRAFFIC also sought information on licensing and regulations regarding commercial aquaculture of paddlefish. This question was prompted by the number of states that in 2000 reported being "not aware" of such activity, which suggested that commercial aquaculture of paddlefish was not regulated closely enough in some jurisdictions for there to be certainty.

The results of TRAFFIC's telephone survey were substantially similar to information provided by state authorities for the 2000 CITES Significant Trade Review. Asked whether there was believed to be commercial aquaculture of paddlefish ongoing within the state, TRAFFIC received negative responses from fisheries and wildlife agencies in Alabama, Arkansas, Indiana, Iowa, Kansas, Louisiana, Michigan, Minnesota, Mississippi, Montana, Nebraska, North Dakota (where such activity is illegal), Oklahoma, South Dakota, Texas, and Wisconsin (TRAFFIC telephone survey of state and provincial fisheries and wildlife agencies, 2002–2003).

TRAFFIC received positive responses from Illinois, Kentucky, Missouri, Ohio, and Tennessee. Illinois reported that there are nine facilities in the state with permits; however, three of these are owned by the same individual and another is a research institution affiliated with a state university. Therefore, the number of commercial paddlefish operations is more accurately five. Illinois also reported that there has been one operation licensed to rear shovelnose sturgeon, although whether it is actually doing so is uncertain. Kentucky reported that there are several commercial operations licensed to rear paddlefish, but it is unclear how many of these may actually have the fish. Missouri has at least one fairly significant commercial operation rearing paddlefish, and publishes a list of fish dealers licensed to rear and sell farmed paddlefish in the state. Ohio reported one approved commercial operation rearing paddlefish, licensed through the Ohio Division of Wildlife. Tennessee licensed its first private paddlefish aquaculture operation in 2001. Along with these states, Georgia also reported that there were six companies or individuals with valid, unexpired licenses to produce, sell, or hold paddlefish, but none are believed to be currently rearing or selling paddlefish in the state (TRAFFIC telephone survey of state and provincial fisheries and wildlife agencies, 2002–2003).

Unfortunately, as had been surmised, it proved impossible from the information available to determine with certainty exactly how many private or commercial operations might be rearing paddlefish in the United States. TRAFFIC's telephone survey found that not all states require species-specific licenses or permits from state fish and wildlife agencies for the practice. Several states (e.g., Arkansas, Iowa, Kansas, and Texas) employ general aquaculture permits for approved species, using what are sometimes referred to as "clean" lists. In other states (e.g., Alabama and Mississippi), aquaculture of native species such as paddlefish falls under the regulatory

purview of state agriculture agencies rather than fisheries or wildlife agencies (TRAFFIC telephone survey of state and provincial fisheries and wildlife agencies, 2002–2003).

TRAFFIC's survey therefore found a somewhat paradoxical situation. On the one hand, in some states that reported licensed commercial aquaculture operations involving paddlefish, it was not possible to determine how many operations (if any) actually have the fish. On the other hand, in some other states where state fisheries agencies reported that they did not believe that such activities were underway, it is not out of the realm of possibility (nor would it necessarily be illegal) for there to be commercial aquaculture operations that are rearing paddlefish. As is discussed in section 6.3 below, and again later in the conclusions and recommendations of this report, the lack of specific information about, and oversight of, commercial paddlefish aquaculture in some U.S. states is of concern to TRAFFIC.

One other initiative is worth noting for the purposes of this report. In addition to the aforementioned commercial aquaculture operations, there has been a proposal to "reservoir ranch" paddlefish in Kentucky waters. This idea differs somewhat from other aquaculture initiatives in that it would use public waters and be financed at least in part by the state. The concept is to stock certain reservoirs in Kentucky with 12–14 inch female paddlefish, and then allow them to grow out naturally over a period of years. For example, a 2,000 acre reservoir could be stocked with 20,000 paddlefish over a 10-year period. At the close of the period, after fish had matured, fishermen that are approved by the state would fish out the waters to sell the roe and other products; a portion of the proceeds would be allotted to continuing the stocking program. According to the proposal, after 10 years public investment would end; if the program involved enough bodies of water, the proposed program could eventually fund itself. The proposal anticipates benefits to the fishermen and other private participants involved, as well as to wild paddlefish populations because of the development of an alternative source of roe (pers. comm., S. Mims, Kentucky State University, 2001).

In the spring of 2002, the Kentucky state legislature passed a joint resolution entitled "Reservoir Ranching HJR 210," that authorized and directed Kentucky State University, in cooperation with the Kentucky Aquaculture Task Force and the Kentucky Department of Fish and Wildlife Resources, to conduct a series of public meetings and a mail-out survey relating to public support and regulation of reservoir ranching of paddlefish in Kentucky public waters. In January 2003, a final report on the implementation of the resolution presented arguments in favor of the concept and survey results indicating a degree of public support among those polled. The report also outlined concerns expressed by the Kentucky Department of Fish and Wildlife Resources about the use of public lakes in Kentucky for a private, commercial enterprise, as well as concerns about the biological, economic and social impacts of the proposal (Kentucky State University et al. 2003). Whether Kentucky will proceed with reservoir ranching is unknown at the time of this report.

Lake Sturgeon

Information provided for the 2000 CITES Significant Trade Review, as well as for TRAFFIC's 2002–2003 telephone survey of state and provincial fisheries and wildlife agencies, confirmed the presence of commercial aquaculture operations involving lake sturgeon only in Minnesota in the United States, and Ontario in Canada.

Responding to the 2000 CITES Significant Trade Review for lake sturgeon, Minnesota reported three licensed aquaculture farms focusing on the species. Only one operation was believed to have a mature population. That operation obtained 75 juvenile sturgeon from the First Nations Manitou Tribe in Ontario; the source of the fish was the Rainy River (Linda Erickson-Eastwood, *in litt*. to Teiko Saito, USFWS for Significant Trade Review, August 23, 2000). Among other states in the lake sturgeon's historic range, Alabama, Arkansas, Illinois, Louisiana, Montana, New York, Tennessee, and Vermont reported no commercial aquaculture operations involving the species in their responses to USFWS. Kansas, Michigan, Ohio, and South Dakota were unaware of anyone culturing lake

sturgeon privately. Wisconsin reported that commercial rearing was prohibited, although industry was working to change the law. Pennsylvania reported that commercial aquaculture of lake sturgeon was illegal without a special permit.

During the same 2002–2003 telephone survey in which TRAFFIC attempted to determine whether there was more recent information on commercial aquaculture of paddlefish, TRAFFIC also inquired about ongoing or new initiatives regarding lake sturgeon. Among U.S. states surveyed, only Minnesota confirmed the continuing presence of commercial aquaculture operations licensed to have lake sturgeon. Responses indicated that there is no ongoing commercial aquaculture of the species in Alabama, Arkansas, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Mississippi, Missouri, Montana, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, West Virginia, and Wisconsin. North Dakota and Wisconsin further reported that state laws prohibit any commercial aquaculture of lake sturgeon (TRAFFIC telephone survey of state and provincial fisheries agencies, 2002–2003).

Somewhat similar to the debate over reservoir ranching of paddlefish in Kentucky, it is worth noting that there has been a debate over Wisconsin's prohibition on commercial aquaculture of lake sturgeon. The debate has revealed two distinct philosophies in the state toward private aquaculture of the species. The first is supported primarily by the Wisconsin Aquaculture Association (WAA), which believes that lake sturgeon are a marketable and potentially lucrative fish that could and should be reared commercially in the state, especially in light of growing demand for domestic caviar and meat precipitated by the decline of Caspian Sea fisheries. The other is supported by the Wisconsin Department of Natural Resources (DNR) and the Sturgeon Management Assessment Team (SMAT), which advocate keeping the current commercial prohibition in place, but would support involving private aquaculture in the propagation of lake sturgeon for research and rehabilitation purposes.

In a December 2000 report to the Wisconsin State Legislature, the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) and Wisconsin DNR outlined the pros and cons of five options for the legislature to consider. These options included:

- Continuing the status quo (i.e., no private aquaculture);
- Creation of a Wisconsin Lake Sturgeon Aquaculture Agreement (WLSAA) and cooperative partnership agreement that would allow propagation by private commercial operations for research and rehabilitation purposes, but not for caviar, meat, or aquarium sales;
- Organization and establishment of a Lake Sturgeon Commercial Management Board that would be given statutory authority to determine conditions for the operation of public and private commercial lake sturgeon operations in Wisconsin, including public hatcheries;
- Development of a Wisconsin Lake Sturgeon Commercialization Pilot Project that would allow a specified number of commercial operations to participate with SMAT in research and rehabilitation activities, and also to sell a predetermined number of lake sturgeon at the operator's discretion; and
- Full legalization of commercial activities (Wisconsin DATCP and Wisconsin DNR 2000).

Whether Wisconsin will relax its current prohibition on private and commercial aquaculture of lake sturgeon is unknown at the time of this report. However, the Wisconsin debate is illustrative of the occasional tension that arises between private interests and their supporters on the one hand, who want to explore the full commercial potential of the fish, and on the other hand those whose primary concern is the conservation of wild lake sturgeon populations. For the latter group, concerns such as the potential for illegal laundering of wild roe, illegal stocking, accidental releases, genetic mixing, and issues related to fish health outweigh the potential benefits of commercial aquaculture. As with the case of reservoir ranching of paddlefish in Kentucky, debate is likely to continue within states such as Wisconsin over the relative merits and drawbacks of commercial aquaculture for lake sturgeon.

In Canada, TRAFFIC found indications of ongoing commercial aquaculture of lake sturgeon only in Ontario, which reported two operations licensed to have the species. However, similar to the case of commercial aquaculture of paddlefish in some U.S. states, Ontario cautioned that the issuance of licenses approving commercial aquaculture did not necessarily indicate that the operations involved were actively rearing lake sturgeon. Ontario also reported that there has been some commercial aquaculture of lake sturgeon carried out in the province by First Nations groups. The status of such operations was uncertain; the facilities do not need approval or licensing from provincial authorities if they are on sovereign tribal lands (pers. comm., M. Muschett, Ontario Ministry of Natural Resources, February 2003).

Alberta, Manitoba, Quebec, and Saskatchewan reported no commercial aquaculture of lake sturgeon. In addition, Alberta, Manitoba, and Saskatchewan noted that commercial aquaculture of sturgeon would require provincial approval and a license; lake sturgeon are not currently on any of these province's approved species lists. Action would be needed at the provincial level to put policies and regulations into place before licensing any commercial operations (e.g., in Manitoba the current ban on possession of lake sturgeon would have to be modified). Although some interest has been expressed, it would likely take some time to assess the pros and cons of lake sturgeon aquaculture, and to conduct the risk assessment protocols necessary to satisfy provincial authorities about issues such as water discharge, escapement, genetic mixing, and other potential environmental consequences and impacts on wild lake sturgeon populations (TRAFFIC telephone survey of state and provincial fisheries agencies, 2002–2003).

White Sturgeon

Commercial aquaculture of white sturgeon is at its most advanced state in California, where roe and meat are produced at several facilities. The exact level of overall production is difficult to pin down. Secor et al. (2000) reported that production of white sturgeon by two U.S. companies exceeded 900 metric tons (990 tons), a level equivalent to peak historical landings for the species. Stolt Sea Farm, believed to be the largest producer of commercially farmed white sturgeon, reported production of 182 tons (163.8 metric tons) in the year 2000 (Stolt Sea Farm 2001b).

Regarding caviar production, an article published in 1999 reported that Stolt Sea Farm had produced 3,000 pounds (1.35 metric tons) of caviar for that year, and aspired to increase production to at least 10 tons (9 metric tons) within five years (Wine Spectator 1999). More recent information from the company suggests that its caviar production is indeed rising. Stolt Sea Farm estimated that total caviar production for the state was approximately 8,000 pounds (3,636 kg) in 2000, and 7,000 pounds (3,182 kg) in 2001. In 2002, Stolt Sea Farm estimated that its production would be 10,000 pounds (4,545 kg) (pers. comm., P. Struffenegger, Stolt Sea Farm, 2002).

As of 2001, Oregon had one legal operator who is permitted to take up to six females per year. Fertilized eggs are surgically removed, and the fish are then returned to the wild. Offspring, which at one time provided broodstock to California, now go to aquariums or for ornamental pond use. Prior to legislative action in the late 1980s that placed a moratorium on further permits, there were two such operations, but one has since ceased (pers. comm., K. Melcher, ODFW, June 2001; R. Beamesderfer, S. P. Cramer & Associates, *in litt*. to TRAFFIC North America, September 2001).

Other white sturgeon aquaculture activities in the U.S. Pacific Northwest include a College of Southern Idaho research program in cooperation with the state of Idaho, and an aquaculture feasibility research program implemented by the Columbia River Inter-Tribal Fish Commission working with Abernathy Hatchery (R. Beamesderfer, S. P. Cramer & Associates, *in litt*. to TRAFFIC North America, September 2001). It is not believed that any of these programs have developed to the point where they are producing significant amounts of caviar.

Outside of the Pacific Northwest, TRAFFIC found only one current case of white sturgeon being held privately. In the course of

TRAFFIC's 2002–2003 telephone survey regarding commercial aquaculture of paddlefish and lake sturgeon, Nebraska reported the presence of one operation believed to be rearing white sturgeon in that state (pers. comm. G. Mestl, Nebraska Game and Parks Commission, January 2003).

Commercial aquaculture of white sturgeon remains in the initial stages in British Columbia. In 2000, two companies obtained government permits to raise white sturgeon commercially (Malaspina University 2000). It is too early to predict the future viability of these endeavors. B.C. government data record that white sturgeon are being cultured in limited or experimental quantities only (B.C. Fisheries 2001c).

6.3 Discussion

Captive rearing of North American Acipenseriformes, whether for purposes of recovery, restoration, stocking, or commercial aquaculture, raises a number of complex issues and challenges regarding the conservation of native species. Some of the conservation issues involved pertain to captive propagation and commercial aquaculture equally; others apply specifically to one or the other of these activities. For example, whereas the potential for accidental releases and disease transmission concerns both commercial aquaculture and captive propagation facilities, captive propagation programs that focus on the deliberate release of fish must also address issues such as the impact on endemic populations of ecological and genetic interactions, habitat availability, and other related factors. The following discusses some of these issues, as well as the benefits and drawbacks of both captive propagation and commercial aquaculture.

Captive Propagation

As was detailed in Section 6.1, captive propagation of paddlefish and sturgeon species by government fish and wildlife agencies is widespread in North America, and the United States in particular. Carefully managed, such programs can convey both conservation and economic benefits, as well as providing the basis for research to better understand acipenseriform species. Captive propagation programs, however, are not a panacea for all the threats and challenges facing wild sturgeon and paddlefish populations, and cannot fully replace in situ conservation programs.

General benefits of captive propagation and stocking programs can include assisting in the recovery of acipenseriform populations that have been depleted by habitat loss, pollution, overfishing, and other factors. Such programs can supplement weak year-classes, aid in the recovery of endangered or threatened species, and increase our knowledge of wild stocks [Leber (1999), cited in Wakeford (2001)].

The specific reasons behind captive propagation initiatives for North American Acipenseriformes, and the potential benefits, vary by species. For species such as the paddlefish and lake sturgeon, captive propagation and stocking programs allow fisheries managers to reintroduce the species into areas of historic distribution, return genetic strains to waters where they are either locally extirpated or nearly so, and can help to maintain populations that are abundant enough to sustain sport (and possibly even commercial) fisheries. For example, captive propagation programs in Kansas and Oklahoma have used captive-bred paddlefish to repopulate some rivers and lakes where dams have blocked natural migration; at the same time both states are developing these waters as economically beneficial recreational fisheries. Michigan, Minnesota, and Wisconsin are pursuing similar management strategies for the lake sturgeon, and Tennessee is in the early stages of trying to restore a population of lake sturgeon to waters from which natural populations disappeared years ago.

Along the U.S. East Coast and Gulf of Mexico, captive propagation programs underway for the Atlantic, Gulf, and shortnose sturgeons may similarly help to restore these species to rivers where populations are extirpated or severely depleted and may not be capable of recovery without stocking for reintroduction or augmentation purposes. These initiatives are integral to federal and state recovery efforts for the ESA-listed shortnose and Gulf sturgeons, as well as for the non-listed, yet depleted, U.S. populations of Atlantic sturgeon. Recovery plans for the Gulf and shortnose sturgeons emphasize a goal of being able to de-list the

species within the next several decades. Long-term goals for the Atlantic and Gulf sturgeons include the restoration of spawning stocks to population levels that can support sustainable fisheries (USFWS/GSMFC 1995; ASMFC 1998b; NMFS 1998).

For other North American sturgeon species or sub-populations, captive propagation may prove to be the only way to prevent extinction. Such is the case with the Alabama and pallid sturgeons, for which there is little or no contemporary evidence of natural reproduction within these species' historic ranges. The Kootenai, Nechako, and Upper Columbia River populations of white sturgeon provide examples of genetically distinct sub-populations that could disappear unless captive propagation efforts to promote their recovery succeed.

Notwithstanding the many potential dividends, however, using captive propagation as a recovery or restoration tool is neither a simple matter nor an overall solution to the challenges facing conservation of North American Acipenseriformes. There are significant obstacles to overcome if captive propagation and stocking programs are to succeed. There are also many unanswered questions regarding the efficacy of such programs, particularly in light of how much remains unknown about acipenseriform species.

Obstacles, risks, and questions related to captive propagation programs fall into several categories. One group of concerns regards the twin imperatives of maintaining the genetic integrity and variability of sturgeon and paddlefish populations. Tringali and Leber (1999, cited in Wakeford 2001) described hazards that lower the genetic diversity in native populations, including those posed by the transfer of exogenous genes by hatchery-reared sturgeon into populations of wild sturgeon, those stemming from genetic changes in the hatchery population regardless of the source of broodstock, and those related to the genetic swamping of natural populations by successful stock enhancement. Secor et al. (2000) noted that there are important unanswered questions about the efficiency with which stocked fish recruit into an endemic breeding population or initiate their own spawning populations, as well as important issues related to the ecological and genetic consequences of their interactions with wild sturgeon. Negative impacts to endemic populations because of competition for future genetic contributions should also be considered with regard to large releases of juveniles from limited parentage (Secor et al. 2000).

The conservatism and caution indicated in breeding and stocking protocols for species such as the Atlantic, Gulf, shortnose, and white sturgeons, as well as the care that state and federal authorities have shown in attempting to limit stocking of lake sturgeon and paddlefish strains exclusively to their own native water systems when possible, suggest that U.S. authorities engaged in captive propagation are sensitive to such considerations. Even so, and notwithstanding the protocols established to address genetic concerns (e.g., use of broodfish from the same strains or rivers in which stocking will occur whenever possible, obtaining an adequate effective population size of broodfish to maintain genetic diversity, avoiding gene swamping from small numbers of breeding pairs, etc.), some possible impacts of captive propagation and stocking cannot be definitively predicted.

For example, it remains uncertain whether, and to what degree, hatchery-reared sturgeon may develop the "homing" behaviors believed to be present in wild populations, or conversely to what degree captive-propagated fish may "stray" from the rivers into which they are stocked. This subject is especially important as it regards captive propagation and stocking programs for anadromous species such as the Atlantic, Gulf, shortnose, and white sturgeons. Secor et al. (2000) noted that homing is perhaps the most difficult ecological issue related to sturgeon restoration because, with the exception of salmonids, homing mechanisms and behaviors are poorly understood in fishes. Because of long generation times, homing will be especially difficult to understand for sturgeons; it remains unknown whether hatchery-produced juveniles will return as adults to systems into which they were stocked as many as 5 to 25 years previously. Furthermore, straying by captive-propagated sturgeon away from waters into which they are stocked could contribute to genetic and ecological impacts to adjacent, possibly depleted, populations (Secor et al. 2000).

How to promote imprinting behavior is therefore an important concern if stocking of hatchery-reared sturgeon is to succeed in enhancing or restoring the population of a particular river (Wakeford 2001). Wakeford cited preliminary data for stocked shortnose sturgeon as indicating that the fish tend to stray if they are stocked at ages greater than one year, and speculated that the sturgeon by that age may have already been imprinted with water from the hatchery. Under this theory, the sturgeon may attempt to return to the hatchery when it is time to spawn, rather than to the river into which they are transplanted. This raises difficult issues, because it suggests that in order for hatchery fish to imprint on the river into which they are stocked, they must either be stocked prior to the age of imprinting (which in species such as the Gulf sturgeon likely occurs at a very early stage), or the hatchery must use water from the river into which the fish will be stocked. Stocking prior to imprinting reduces the probability of survival, and can interfere with the evaluation of the stocking program's success because marking very young fish for future identification is difficult. Using water from the target river presents the issue of disease, parasites, and larval predators in raw surface waters that can interfere with survival in the hatchery, while treating such water prior to hatchery use may alter its usefulness for imprinting (Wakeford 2001).

Another category of concern regarding captive propagation and stocking programs for North American Acipenseriformes regards disease transmission. Despite precautions taken at hatcheries to prevent the introduction of dangerous pathogens to wild populations, captive propagated fish could still introduce disease to wild stocks. Many sturgeon pathogens that affect fish in culture are widespread, and understanding of such diseases is incomplete (Wakeford 2001). As detailed above, the discovery of an iridovirus in captive pallid sturgeon necessitated the destruction of entire year-classes of fish. That situation provided an instance in which careful monitoring detected and eliminated a potential threat to wild populations had the fish been released, as well as a cautionary tale about the dangers of disease in even closely monitored federal hatcheries.

There is also a potential for the accidental release of fish from hatcheries which, along with disease concerns, raises questions of diluting wild genetic strains and increasing competition for food or habitat. Such considerations need to be weighed against the risk of extirpation in sturgeon populations if stocking is not attempted (Wakeford 2001).

Finally, captive propagation and stocking cannot substitute for habitat conservation and other measures to benefit wild populations. Secor et al. (2000) cited Kozhin (1964) in noting that natural reproduction should be preserved because hatcheries cannot replace all properties of natal populations, which are characterized by complex age structures, and migrations and feeding behaviors. They further noted that in systems where sturgeons are depleted or extirpated, an important issue is whether there is sufficient habitat for spawning, feeding, environmental and predation refugia, and migration. As that paper concisely stated: "It would be a waste of resources to stock millions of juveniles and have no spawning habitats for them to return to as adults." Migration corridors are a principal problem in restoring both sturgeon and paddlefish populations because fish ladders and other mitigation measures have proved ineffective in passing sturgeons through dams and other barriers. Another important consideration in North American systems is the introduction of exotic piscivores in many systems (e.g., largemouth bass and channel catfish in the Chesapeake Bay system) which could decimate populations of stocked sturgeon released at a small size (Secor et al. 2000).

Recovery, restoration, or stocking programs for Acipenseriformes must therefore occur concurrently with measures to recover or restore lost or degraded habitats. Whether water quality, food availability, and spawning habitat are capable of supporting stocked fish can be examined through ecological assessments, small-scale experimental releases (to assess losses of stocked fish to predation, competitive interaction with endemic sturgeons and other fishes, and other possible constraints), and evaluation of the impact of stocked fish on wild acipenseriform populations and other fishes in the receiving waters (Secor et al. 2000; Wakeford 2001). In

many systems where sturgeons are extirpated, deliberate releases may be the only means to evaluate whether the species can continue to undertake feeding, migration, homing, and spawning (Secor et al. 2000).

TRAFFIC's intention in observing these challenges is not to diminish the value of captive propagation programs for the conservation of North America's sturgeon and paddlefish. In the near term, captive propagation is vital to many native acipenseriform species and populations. A tremendous amount of consideration and work has clearly gone into developing captive propagation techniques, protocols, and stocking plans to maximize the benefits to the species involved while trying to minimize the risks to endemic populations. However, the long-term prospects for all of the species involved will ultimately depend upon the restoration and maintenance of natural habitat, so that fish reintroduced into the wild will have an adequate forage base, the ability to migrate seasonally, and access to productive spawning grounds. If too large a percentage of available resources goes toward development of captive propagation programs, and not enough attention is paid to issues such as the damming of rivers, river channelization, pollution, and other fundamental ecological challenges, captive breeding may become an end in itself as prospects for recovery and reintroduction dwindle.

Commercial Aquaculture

Commercial aquaculture of many fish species has been controversial for some time. Between 1987 and 1997, global production of farmed fish more than doubled in weight and value, and in 2000 accounted for more than one-quarter of all fish (and shellfish) consumed by humans (Naylor et al. 2000). On the one hand, some have argued that commercial aquaculture production can compensate for the shortfall in harvests as fisheries deteriorate, or that fish farming can help to restore wild populations by relieving pressure on capture fisheries. On the other hand, it has also been noted that potential damage to ocean, coastal, and riverine resources through habitat destruction, waste disposal, exotic species and pathogen invasions, and large fish-meal and fish-oil requirements needed to produce farmed fish may further deplete wild fisheries stocks. Naylor et al. (2000) pointed to a central paradox: commercial aquaculture is a possible solution, but may also be a contributing factor, to the collapse of fisheries stocks worldwide.

Determining the potential benefits and drawbacks of commercial aquaculture of acipenseriform species in North America, and the linkages between sturgeon and paddlefish farming and conservation of wild stocks, may be even more complex than for other commonly farmed fish species such as salmon, shrimp, carp, tilapia, and catfish. These species and others tend to be farmed either commercially to produce medium- to high-value commodities for regional or global food markets, or by family and cooperative farms to produce low-value food sources for household subsistence or local markets (Naylor et al. 2000). Commercial aquaculture of sturgeon and paddlefish is primarily focused on a different purpose, the production of a very high value (per unit of volume) luxury item—caviar—for a small set of consumers who can afford it. Even the production of meat from farmed sturgeon tends to be directed to a relatively limited gourmet market.

The strongest argument in favor of commercial aquaculture of sturgeon and paddlefish is that it may benefit wild populations by providing an alternative source of roe and meat for consumption. It is also conceivable that commercial aquaculture of Acipenseriformes could alleviate demand for illegally harvested caviar (Secor et al. 2000). In North America, operations such as those in California involving white sturgeon indicate that large-scale farming of sturgeon can produce significant amounts of meat, and there is potential for significant roe production. Once successfully established, it has been theorized that such operations will need only small infusions of broodstock from wild sources.

Given concerns about the potential collapse of the Caspian Sea fisheries that have long produced the vast majority of caviar for the world market, and the additional pressure that such an occurrence would likely place on North American species, commercial aquaculture could therefore prove to be a valuable future source of caviar. Even in the Caspian Sea basin, hatchery reared fish supply

a significant proportion of sturgeon stocks. After the 1962 completion of the Volgograd Dam on the Volga River significantly reduced habitat availability and spawning grounds, the Soviet Union launched an intensive sturgeon ranching program to maintain stocks and production. In 2000 it was estimated that, of the three most valuable commercial species, hatcheries accounted for 26–28% of Russian sturgeon stocks, 30% of stellate sturgeon stocks, and more than 90% of the stock of beluga sturgeon (Secor et al. 2000).

Yet, before concluding that commercial aquaculture will prove beneficial to conservation of North American Acipenseriformes, a number of issues and questions must be addressed. Some of the topics involved parallel those discussed above regarding captive propagation and stocking programs. For example, commercial aquaculture also carries risks related to transmission of disease, accidental release (and subsequent interactions of farmed fish with wild ones) and environmental damage caused by plant construction and discharges. Disease and accidental release are key problems that have been identified for alligator, salmon, and other farming and aquaculture activities (Secor et al. 2000).

In addition, unlike captive propagation programs conducted by public authorities, commercial aquaculture also poses a potential threat to wild acipenseriform populations through deliberate release of fish in non-native waters. Whereas captive propagation programs operate under strict stocking protocols, and are intended to reintroduce or augment wild stocks, commercial aquaculture is a largely private economic activity that is not necessarily constrained by the same interest in maintaining the genetic integrity of wild populations.

There are several possible reasons for the deliberate release of sturgeon or paddlefish from private aquaculture facilities. It has been noted that commercial sturgeon aquaculture requires a significant amount of start-up capital, as well as a long lead-time between establishment and production, necessitated by the sturgeon's lengthy life cycle. These factors suggest that successful commercial aquaculture initiatives involving Acipenseriformes are likely to remain limited in number and involve only companies with ample investment capital. Additionally, the practice conveys a significant degree of economic risk, since fish production is strongly related to maintenance of water quality, and plant failures can result in large losses of fish despite previous investments in their production (Secor et al. 2000). If rising demand for North American caviar leads to a surge in interest in commercial sturgeon or paddlefish aquaculture, there is no guarantee that all such operations will succeed economically, and, for those that may not, there may be a financial incentive to cut losses by dumping fish stocks and moving on to other business.

The likelihood of detrimental introductions rises where imports and commercial aquaculture of exotic species are allowed or facilitated, even when laws or regulations exist that prohibit release of non-native species. Accidental or intentional releases by private aquaculture facilities or aquarists tiring of their hobby have been documented, and highlight the risks. The release of white sturgeon in Alabama and Georgia waters during the 1980s, for example, prompted fisheries authorities to ban the commercial propagation of the species in those states' waters. White sturgeon in captivity are known to harbor two herpes viruses, Herpes I and Herpes II, as well as white sturgeon iridovirus, in their early life stages (Secor et al. 2000; Wakeford 2001; pers. comm., P. Struffeneger, Stolt Sea Farm, 2002). Should further white sturgeon aquaculture develop in regions where depleted populations of sturgeons reside, transmission of these diseases could further deplete those populations (Secor et al. 2000). Recovery plans for the Atlantic, Gulf, and shortnose sturgeons all note the susceptibility of these species to sturgeon viruses endozootic to the west coast, and the need to diligently protect against accidental or deliberate releases (USFWS/GSMFC 1995; NMFS/USFWS 1998; NMFS 1998).

In addition to disease issues, introduction of non-native species or genetically different strains of native species could have a significant impact on wild stocks through competition or hybridization. Hybridization between separate species is well known and documented for sturgeon, and many hybrids are reproductively viable (USFWS/GSMFC 1995; NMFS 1998; Secor et al. 2000; pers.

comm., G. Benz, SARI, 2001). Even if the farmed sturgeon set loose are of the same species, releases could cause deleterious effects to adjacent endemic populations because of ecological and genetic interactions (Secor et al. 2000).

Beyond those issues, TRAFFIC also has concerns related to law enforcement and illegal trade. For species such as the Atlantic sturgeon, lake sturgeon and paddlefish, it is still too early to determine whether commercial aquaculture is truly viable. Commercial aquaculture of Atlantic sturgeon in Canada and the United States remains at a relatively small or experimental scale. There are questions about whether the lake sturgeon, with its slow growth rate and very late age at sexual maturity, is an economically feasible species for commercial aquaculture. No paddlefish operations have yet reached a stage where captive-bred fish are producing significant amounts of caviar for the commercial market; the main product to date has been fertilized eggs and fry for research or the establishment of new aquaculture operations in North America and abroad. To date, caviar and meat products coming from companies that may be engaged in commercial aquaculture of paddlefish are believed to have actually come from the wild. It is not certain what percentage of fertilized eggs and live fry currently marketed by aquaculture facilities may also be derived from wild stocks. As was noted in section 6.2, there are even questions about whether some registered facilities are raising paddlefish at all. It is likely to be some years before such operations develop to the point that their true potential and impact can be measured.

In this atmosphere, the danger arises that commercial aquaculture operations, if not carefully monitored, have the potential to serve as laundering facilities for illegally taken or obtained paddlefish or sturgeon products. TRAFFIC is further concerned that in several states, wildlife and fisheries agencies have not yet developed regulatory plans to exercise careful oversight of the industry, or, in some states, do not have regulatory jurisdiction over commercial aquaculture activities for species that are not considered endangered or threatened. While there are indications that states are increasingly concerned about this issue, as of the time of this report it is unclear what specific remedial steps might be taken. The existing regulatory and information gaps on this subject may represent a loophole for potential or actual abuse.

Of particular concern to TRAFFIC is that the lack of tight regulatory monitoring of paddlefish aquaculture in some U.S. states may create a loophole for illegal trade. In certain states the situation is exacerbated by the separation of regulatory oversight of commercial aquaculture from that of commercial and recreational fisheries. As was discussed in Section V, in past decades paddlefish roe was not in high demand, and therefore commercial aquaculture for the production of paddlefish caviar may not have been economically viable. As demand and prices for paddlefish roe have risen in recent years, so too have the prospects for commercial aquaculture to become a profitable supplement to roe from wild-caught fish. Without closer scrutiny from regulatory authorities, however, it will be impossible to determine that all caviar reported from commercial facilities has actually been farmed, rather than having been produced from wild sources.

Finally, TRAFFIC questions the premise that commercial aquaculture is likely to substantially relieve pressure on wild North American acipenseriform populations from capture fisheries. Naylor et al. (2000) noted that despite significant increases in farm production of salmon, worldwide catches of wild salmon actually rose by 27% between 1988 and 1997, even as international prices for four of the five main wild species (chinook, coho, pink, and chum) declined by 30–50%. Similarly, wild capture of hake and haddock remained stable during the 1990s despite rapid growth in alternatively farmed fish such as tilapia. That study found little obvious effect of aquaculture production on capture rates of wild fish, and surmised that the ability of the aquaculture sector to replace or provide market alternatives for wild catches depends significantly on the economics and policies of fisheries.

In the case of North American Acipenseriformes, TRAFFIC likewise doubts that commercial aquaculture will have a significant impact on the demand for caviar from wild sources, at least in the near term. As

was discussed in the review of the global caviar trade in Section 5.1, North American imports of sturgeon caviar into the U.S. alone far surpassed domestic roe production from wild and farmed sources combined during the late 1990s and 2000. For North America to produce enough roe to meet only its own apparent market demand for caviar (should imports decrease dramatically) would require a significant increase in domestic production from all sources.

In the short term, the ability of commercial aquaculture to contribute substantially to such an increase in production appears unlikely. As noted above, the estimate for caviar production from the largest farmed source, white sturgeon in California, was only 10,000 pounds for 2002, and significant production from other species remains some time distant. Proposed concepts such as "reservoir ranching," which more closely resembles the Russian model of rearing and stocking large numbers of Acipenseriformes for later harvest, could help to increase production within 8 to 10 years. Proponents argue that reservoir ranching as practiced in other parts of the world has shown evidence of being a low-input, sustainable, nonpolluting stock enhancement production system for growing food fish. However, such proposals generate their own biological concerns (e.g., the potential effects on the aquatic food chain, increased competition among fish species in various life stages for a limited food supply, the impact of paddlefish gill net harvests on other sport fish), as well as questions about whether it is appropriate to use public waters to support private aquaculture (Kentucky State University et al. 2003). In addition, like other stocking programs, reservoir ranching initiatives must be sensitive to genetic and disease considerations. For example, while rearing and releasing large numbers of paddlefish for future harvest into closed reservoirs in their native range in the Mississippi River Basin may turn out to be feasible, it would clearly be a poor idea to allow the release of non-native species (e.g., white sturgeon) into east coast or Mississippi River drainage systems for commercial purposes, given the issues of ecological impact, disease transmission, and hybridization.

As with captive propagation, TRAFFIC does not raise these issues to argue against the commercial aquaculture of North American paddlefish and sturgeon. Whether or not commercial aquaculture of these species should be allowed is no longer a question. The practice already exists, and, properly managed and overseen, can provide a legal source of domestic meat and caviar as an alternative to wild catch. TRAFFIC seeks to point out that commercial aquaculture is likely to provide only a supplement to, rather than a replacement for, such commercial catch. Furthermore, it is likely to be increasingly important for North American jurisdictions to establish and follow strict policies, protocols, and regulations regarding commercial aquaculture of sturgeon and paddlefish, as they have for captive propagation of several North American sturgeon species, to prevent harm to wild populations. Assuming that demand for caviar from domestic acipenseriform species will continue to rise in light of uncertainties about the situation in the Caspian Sea, incentives for individuals or companies to get into the business will likely increase, and it is imperative that wildlife authorities be in a position to address potential negative as well as positive consequences.

VII. Conclusions and Recommendations

North America's sturgeon and paddlefish face an uncertain future. While no native species has yet become extinct, all face significant challenges to their long-term survival because of the negative consequences of human activities (e.g., overfishing, habitat degradation or alteration, pollution, etc.). Although the specific impacts vary among individual species, conservation of remaining stocks will require careful attention to the ecological needs, unique life history characteristics, and sensitivity to catch exhibited by these fish.

This section summarizes the information gathered by TRAFFIC for this report; outlines TRAFFIC's general conclusions; and presents a set of recommendations regarding the conservation, management, and trade of North American paddlefish and sturgeon.

7.1 Species Status/Conservation Challenges

Summary/Conclusions

- IUCN lists all but two North American acipenseriform species as vulnerable or critically endangered. The United States and Canada also classify several species or individual populations as endangered, threatened, or in need of special protection. The species listed in each of these two countries, however, differ.
- In the United States, three sturgeon species and one subpopulation (the shortnose sturgeon, Alabama sturgeon, pallid sturgeon, and Kootenai population of white sturgeon) are listed as endangered under the ESA. The Alabama sturgeon, pallid sturgeon, and Kootenai River white sturgeon face the very real possibility of extinction, at least in the wild, because of poor natural recruitment. The Gulf sturgeon is listed as a threatened species under the ESA.
- In Canada, the shortnose sturgeon, white sturgeon, and green sturgeon are classified federally as species of special concern. White sturgeon and green sturgeon populations are further classified as imperiled or critically imperiled by the province of British Columbia, which is the only Canadian jurisdiction inhabited by these species.
- Available information differs greatly regarding the status, life histories, and ecological needs of North American acipenseriform species. While more research is needed on all species, TRAFFIC noted a lack of available data for the green sturgeon in particular. In late 2001, the U.S. government was petitioned to list the species as threatened or endangered under the ESA. The subsequent NMFS review during 2002 found that there are two distinct population segments of green sturgeon, and that the species may currently spawn in as few as three river systems in Oregon and California. NMFS concluded, however, that an ESA listing is not warranted at the present time.
- TRAFFIC also noted a lack of data on the status and abundance of the shovelnose sturgeon in many portions of its range. In the past, the species was often considered a nuisance or "trash" fish, and its management and conservation have often received less attention than have other acipenseriform species such as paddlefish, lake sturgeon, and pallid sturgeon that share major portions of its range.
- Throughout North America, over the past century or more, the needs of human populations for navigation, power generation, flood control, irrigation, and waste disposal have changed the flow and temperature regimes, sedimentation levels, and even the very courses of vital rivers that paddlefish and sturgeon inhabit. Damming, channelization, dredging, pollution, and other anthropogenic modifications of North

America's river systems have reduced the historic range of all North American Acipenseriformes, and every species has lost spawning grounds. Some species that once had broad distribution patterns and could migrate freely now exist only in isolated or segmented sub-populations, with uncertain long-term consequences to their genetic variability and long-term viability.

- It is also clear that North America's sturgeon and paddlefish species continue to suffer the effects of past overfishing. Historical catch levels indicate that most of these species were at one time abundant in their native waters; the only species believed to have always been rare is the pallid sturgeon. Yet, even though most of the commercial fisheries peaked at the end of the nineteenth century, or early in the twentieth century, North America's paddlefish and sturgeon species have yet to rebound to historic population levels. Factors including long lives, slow rate of sexual maturation and reproduction, and loss of spawning habitat combine to ensure that full recovery will be a very protracted process—if it is possible at all for some species.
- Under these circumstances, there is no quick or easy way to recover North American Acipenseriformes to levels where they might sustain significantly increased commercial catch for caviar, meat, or other products. Even those species that are relatively abundant and currently sustain some commercial catch and trade (paddlefish, shovelnose sturgeon, and white sturgeon in the United States; Atlantic sturgeon and lake sturgeon in Canada) will likely require conservative management to ensure their continued viability.

Recommendations

- *States and provinces that have not already done so should conduct immediate biological surveys of their current sturgeon and paddlefish populations. In the United States, a range-wide stock assessment is especially important for the shovelnose sturgeon, which, while considered in many states to be locally abundant, has often not been carefully monitored.*
- *In states with commercial fisheries, such population surveys should be undertaken cooperatively among federal, state, and provincial fisheries biologists and commercial fishermen, to ensure to the extent possible that there is consensus among these often divergent interest groups about the state of the resource base. In researching this report, TRAFFIC noted often very different opinions between state management authorities and commercial fishermen regarding the status of stocks, particularly of paddlefish, in various states and water bodies. TRAFFIC urges fisheries managers to include the commercial fishing industry in efforts to determine stock and sustainable catch levels.*
- *Although the NMFS 2002 status review of the green sturgeon found that listing as a threatened or endangered species of the ESA is not warranted at the present time, further scientific review is needed to clarify its status, precise life history, spawning areas, and habitat needs. While the green sturgeon is not considered a major species in trade, the possibility that the species may be limited to as few as three remaining spawning rivers certainly warrants additional measures to identify and conserve remaining habitat that is critical to the species' continuing viability.*

7.2 Management and Regulation

Summary/Conclusions

- The ways in which individual North American acipenseriform species are legally classified vary at the federal, state, or provincial levels in the United States and Canada, as do the purposes for which they are managed.
- In the United States, the ESA-listed Gulf sturgeon, shortnose sturgeon, Alabama sturgeon, pallid sturgeon, and Kootenai River population of white sturgeon are subject to recovery plans and/or federal/state cooperative agreements as mandated under that law. These species generally also receive protection under endangered species statutes in the states they inhabit.

- Commercial and sport catch of Atlantic sturgeon has been prohibited in all U.S. waters since 1998, under a moratorium recommended by the Atlantic States Marine Fisheries Commission.
- U.S. populations of the paddlefish, shovelnose sturgeon, white sturgeon, and green sturgeon are commercially and recreationally fished in some but not all of the range states these species inhabit.
- Paddlefish may be commercially caught in seven of the 21 states in which the species is extant, and may be sport-caught in 15 states; catch regulations differ by state. Reported paddlefish catch and roe harvest increased significantly in some states in recent years. Part of the increase may be due to more aggressive enforcement of reporting requirements. However, contemporary, comprehensive data on paddlefish catch and roe harvest are not available for all states.
- Shovelnose sturgeon may be commercially fished in eight range states, and sport fishing is legal in 14 states; catch regulations differ by state. As with paddlefish, reported harvest of roe increased significantly in some states in recent years, but comprehensive data are not available for all states.
- Oregon and Washington allow both commercial and sport catch of white sturgeon. Since 1989, the primary white sturgeon fishery in the lower Columbia River has been managed for optimum sustained yield (OSY). Since 1996, Oregon and Washington have managed the fishery under a joint state agreement; the commercial fishery is also subject to the framework of the congressionally established Columbia River Compact. The determination of annual catch limits and other restrictions is largely based upon surveys and abundance estimates of white sturgeon stocks. California allows only sport catch of white sturgeon.
- Oregon and Washington do not allow directed commercial catch of green sturgeon, but do allow green sturgeon caught in other commercial fisheries to be kept, and also allow sport fishing. California allows sport fishing and some catch of green sturgeon in Native American fisheries.
- The lake sturgeon is classified as a threatened or endangered species in many of the species' U.S. range states. No state allows commercial fishing for lake sturgeon, but three states (Michigan, Minnesota, and Wisconsin) allow limited sport catch.
- In Canada, commercial and recreational fishing for Atlantic sturgeon is legal in the Maritime provinces and in Quebec. The "sunset" fishery in the Maritime provinces is under the jurisdiction of the Department of Fisheries and Oceans, and is regulated through a seasonal closure to protect spawning populations, a minimum size limit, and gear restrictions. Maritime fishing regulations do not preclude the catch of shortnose sturgeon, although the minimum size restriction makes legal retention unlikely. The Quebec fishery is managed by provincial authorities; regulatory restrictions include limiting the number of licensed fishermen, a catch quota, a slot limit on legal fish, gear restrictions, and a seasonal closure.
- Quebec and Ontario were the only Canadian provinces with active commercial fisheries for lake sturgeon as of 2002, and both provinces have established catch quotas and reporting requirements. Saskatchewan has a federal lake sturgeon quota, but no commercial fishing is allowed under a provincial moratorium. Alberta, Ontario, and Quebec allow sport catch of lake sturgeon, while Manitoba and Saskatchewan do not (although there is some catch-and-release fishing).
- Canadian stocks of white sturgeon and green sturgeon have been classified as species of special concern by COSEWIC, and various population segments are further classified as imperiled or critically imperiled by the provincial government of British Columbia. There is no commercial or sport catch allowed for either species, although British Columbia has allowed limited catch-and-release fishing for white sturgeon in some segments or tributaries of the Fraser.
- Many U.S. states and Canadian provinces have tightened regulations governing commercial and sport catch in recent years. However, the management regimes that apply to some North American

acipenseriform species and populations in North America continue to be those that were developed during years of moderate market demand for domestic caviar. In recent decades, prices for caviar from North American species were relatively low compared to those for imported Caspian Sea species, which served to diminish the incentives for fishermen, wholesalers, and retailers to exploit native species. Recent price trends for caviar from North American species suggest that this situation is changing, and management approaches must take these changes into account.

- A review of the adequacy of current regulations is particularly urgent for those acipenseriform species with populations that are abundant enough to support commercial and/or sport catch, i.e., paddlefish, shovelnose sturgeon, and white sturgeon in the United States, and lake sturgeon and Atlantic sturgeon in Canada. Management agencies need to ensure that catch of these species remains at a level that is sustainable if these species are to exist long into the future.
- In the United States, although some states have moved to make their regulations more consistent in recent years, there appears to be a continuing lack of coordination or overall regulatory strategy among jurisdictions concerning paddlefish and/or sturgeon populations. This becomes apparent when examining regulatory regimes pertaining to paddlefish and shovelnose sturgeon management and catch in the Mississippi and Missouri river basins, where even states whose borders are defined by common fishing waters sometimes employ different regulatory requirements and restrictions.

Recommendations

- *All U.S. states that allow commercial catch of paddlefish or sturgeon should implement regulations requiring, at a minimum, the reporting of all catch and harvest of roe to state fisheries agencies. Lack of close monitoring of catch levels may not have been a problem during years in which market demand for North American caviar was low, but history suggests that overfishing can quickly become a problem and lead to significant population declines during periods of high demand. TRAFFIC urges all jurisdictions that allow the catch of these species to review their regulations and determine whether they are adequate to face a situation of increasing demand and exploitation.*
- *Furthermore, U.S. states that allow catch of paddlefish or sturgeon should work to harmonize their regulatory regimes to the extent possible. This is especially true in the Mississippi and Missouri river basins, where neighboring states often share river or other water boundaries with paddlefish and sturgeon populations. Standardization of fishing seasons, length limits, gear restrictions, and reporting requirements across state borders, and especially in common waters, would serve to eliminate a potential loophole in state enforcement efforts.*
- *TRAFFIC is particularly concerned about the long-term sustainability of commercial fishing for shovelnose sturgeon. Historically, there has been a lack of research and baseline data in many states on population status and abundance, critical habitat, reproduction, and sustainable catch rate. States that currently allow commercial fishing of shovelnose sturgeon, but have not conducted thorough research and surveys of their populations to determine whether the species can withstand increased catch, should consider restricting or even suspending commercial fishing for shovelnose sturgeon until such research and surveys can be completed.*
- *In the Canadian Maritime provinces, fisheries regulations for sturgeon should be reviewed and clarified regarding catch and trade of Atlantic and shortnose sturgeon. Current regulations refer only to the catch of "sturgeon." While the 120 cm (48 inch) minimum size restriction in the fishery should largely preclude the catch of shortnose sturgeon, it can be presumed that any legal-size shortnose sturgeon caught would be a very large, sexually mature specimen, whose removal from the population could have implications for the breeding population. DFO should consider clarifying the regulations to specify whether or not catch of shortnose sturgeon is to be allowed.*

- *Every state and province that allows sport catch of paddlefish or sturgeon should adopt regulations that include a reporting requirement for fish caught, such as requiring the physical check-in of fish taken with fisheries authorities, or some other type of reporting requirement. This is especially important for U.S. states that currently allow the sport catch of paddlefish and shovelnose sturgeon without reporting requirements. Given the need for better information about the abundance and composition of stocks of these species— i.e., average size, age, sex, etc.—mandatory reporting could provide useful baseline information to fisheries managers.*

7.3 Legal and Illegal Trade

Summary/Conclusions

- It is unlikely that roe from North American paddlefish and sturgeon species could fully replace the domestic and international demand for caviar currently being served by Caspian Sea species on a sustainable basis. Over the course of the 1990s, the United States alone imported an average of 66 metric tons of caviar annually, in addition to what was produced domestically. U.S. Caviar imports peaked in 1999 at 99 metric tons, then declined to 74 metric tons in 2000. Caviar imports reported by the European Union and Japan during the same period averaged more than 200 metric tons annually, although in 2000 the figure was only 109 metric tons. Should the availability of caviar from the primary sources in the Caspian Sea decrease significantly because of a collapse in the fisheries, reductions in quotas, or increased regulation of international trade, it is highly doubtful that wild populations of North American sturgeon provide a resource base broad enough to sustain that level of demand. Domestic roe production from all sources (wild and farmed) would have to increase by several multiples to approach the level of Caspian Sea production.
- Data are not available to precisely quantify the extent of domestic markets for caviar, meat, or other products from North American paddlefish and sturgeon. In Canada, a comparison of domestic catch versus export records suggests a degree of domestic demand for Atlantic sturgeon and lake sturgeon. In the United States, there are domestic markets for caviar from paddlefish, shovelnose sturgeon, and white sturgeon, as well as some demand for meat.
- A review of USFWS LEMIS data from the late 1990s into 2001 shows that there are export markets for U.S. sturgeon and paddlefish products. The principal species in international trade were paddlefish and white sturgeon. CITES data from Canada showed export markets for sturgeon products, primarily meat, from Atlantic sturgeon and lake sturgeon. The principal external market for Canadian sturgeon products in recent years has been the United States.
- The price of U.S. paddlefish roe in export markets increased in 2001 compared with 2000. However, the value of individual exports varied widely, with exports to some markets valued significantly higher than concurrent exports to other markets. Further data will be needed to determine whether there is a clear trend of increasing prices.
- Overall, CITES implementation for Acipenseriformes has proceeded fairly smoothly in the United States and Canada. However, the decentralized nature of the management and regulatory systems in both countries has presented obstacles in complying with decisions and resolutions of CITES, such as the decision calling for the reporting of annual export quotas. Better standardization of catch regulations and reporting requirements as outlined above could improve the situation.
- Paddlefish and sturgeon roe and meat are perishable products. While careful investigation of export permit applications remains critical, finding ways to streamline the permit process is also important to ensure that legally harvested products can reach their destination markets in optimal condition.
- The United States and Canada could potentially benefit from the development of a uniform labeling requirement as called for in CITES Resolution Conf. 11.13. Presumably, North American caviar exports to the European Union could be prohibited if the two countries do not come into compliance.

- Evidence of poaching and illegal trade indicates that these practices involve many species and numerous jurisdictions. In some areas, illegal activity appears to be fairly localized and sporadic. In other places, particularly the Mississippi and Missouri river basins, there are disturbing reports of more organized poaching and illegal trade rings targeting paddlefish and sturgeon species.
- TRAFFIC is particularly concerned over recent reports of North American paddlefish and sturgeon roe being falsely labeled and sold as Caspian Sea caviar. Recent law enforcement cases (e.g., the Maryland case of the U.S. Caviar and Caviar Company) suggest that this practice can be quite lucrative and injurious to customers buying false product at significantly inflated prices. It is not clear at this time whether these cases represent isolated incidents, or are indicative of a broader new phenomenon in the illegal caviar trade in North America. Further investigation of this matter should be a priority for law enforcement officials.

Recommendations

- *U.S. and Canadian CITES management authorities need to work with states and provinces that allow the commercial catch of paddlefish or sturgeon to investigate ways to increase compliance with recent CITES resolutions and decisions, such as the reporting of annual export quotas. Such a step might be accomplished cooperatively in the United States if all states were to develop consistent catch regulations and reporting requirement. In this way federal CITES management authorities could determine true national catch figures for these species without violating the sovereignty of states and provinces over local fisheries management.*
- *CITES management authorities in the United States and Canada should investigate ways to streamline the system for issuing export permits for sturgeon and paddlefish products. This could be done in cooperation with state fisheries authorities to identify candidates for general findings of non-detriment, as is currently the case for the roe donation programs in Montana and North Dakota. Participants should be required to agree to a protocol for regular inspection or audit of facilities and records to ensure compliance.*
- *CITES management authorities in the United States and Canada should work with the CITES Secretariat, the Animals Committee, and other parties to implement the uniform labeling system adopted by the CITES Parties to the extent that such a system will accomplish the twin goals of improving detection of illegal product and streamlining the permit process for legal product to move into and out of North America.*
- *Law enforcement authorities should be provided with resources to fund special operations and undercover investigations into poaching and illegal trade activities.*
- *States and provinces that permit the sport catch of paddlefish or sturgeon should investigate the feasibility of roe donation programs such as the ones operational in Montana and North Dakota as a way to both increase the utilization of fish routinely taken and also to generate funds for conservation and management. Such programs could increase the volume of paddlefish and sturgeon products in legal trade without increasing current commercial catch levels. Possible candidates for such programs could be sport fisheries for paddlefish and shovelnose sturgeon in some states in the Mississippi and Missouri river basins, lake sturgeon in Canada, and white sturgeon in the U.S. Pacific northwest.*

7.4 Captive Propagation and Commercial Aquaculture

Summary/Conclusions

- Captive propagation by federal, state, provincial, and public-private cooperative initiatives can be a vital component of current paddlefish and sturgeon management and recovery strategies. For the pallid sturgeon and Alabama sturgeon, captive propagation may represent the only hope for long-term species survival. For other species, captive propagation and stocking have proved critical to the reintroduction of species into areas from which they had been extirpated, or in the maintenance of

populations sufficient to support sport or commercial catches.

- North American commercial aquaculture is not yet at a point where it is producing significant enough amounts of caviar to replace or significantly reduce demand for roe from wild-caught or imported sources. Commercial production of white sturgeon is at its most advanced state in California, where caviar production as of 2002 was estimated at about 10,000 pounds (4.5 metric tons). To date, there has been no significant production of caviar from commercially farmed Atlantic sturgeon, paddlefish, shovelnose sturgeon, or lake sturgeon; the main products of enterprises involving these species have been fertilized eggs and fry.
- Both of the above activities, commercial aquaculture in particular, can be controversial. Issues confronting captive propagation and restoration efforts include compromising wild genetic stocks, introduction of non-native diseases into wild populations, broodstock procurement, hybridization, disposition of broodstock and surplus stock, and accidental release of hatchery-reared fish. Commercial aquaculture facilities must also address these concerns. Law enforcement agencies are further concerned that commercial aquaculture facilities may be an avenue to launder illegally taken or obtained wild roe that is misrepresented as aquaculture product for distribution into the legal market.
- Regulatory requirements regarding commercial aquaculture differ. There are federal restrictions that relate to specific species, such as aquaculture of Atlantic sturgeon in ASMFC states. At the state and provincial level, some jurisdictions prohibit the private aquaculture of sturgeon and paddlefish, others allow but closely restrict and monitor commercial aquaculture ventures, and still others allow the practice with little oversight. In the absence of a comprehensive oversight system, it is difficult to determine the precise number of commercial aquaculture ventures involving paddlefish and sturgeon in North America. Complicating the issue are Native American and First Nations captive propagation and commercial aquaculture facilities in the United States and Canada that are subject to specific laws and treaties between the sovereign tribes and the respective state, provincial, and federal authorities.
- Further development of commercial aquaculture could provide benefits to wild paddlefish and sturgeon populations by providing an alternative source of roe and meat. However, the expansion of commercial aquaculture requires careful regulation and oversight to prevent accidental escapes, introduction of non-native species, disease transmission, dilution of wild genetic stocks, hybridization, and the potential for illegal laundering of wild roe into legal markets.
- To ensure that commercial aquaculture meets its goals of providing caviar and other products for North American and international markets while benefiting the conservation of wild populations, strict regulatory protocols and monitoring procedures are needed for the industry.

Recommendations

- *The U.S. and Canadian federal governments and those states and provinces that allow the commercial aquaculture of paddlefish and/or sturgeon species should immediately conduct a complete inventory of all such facilities and operations. Basic information to gather includes the species currently under culture, the amount of pond acreage under cultivation, current and anticipated production amounts and timetables, and the markets being served. Such information would help fisheries managers to realistically assess current actual production levels of roe and meat, and how much is likely to be produced and marketed in the short and long terms. It would also provide a mechanism to help authorities prevent the illegal laundering of roe or meat from wild populations through such facilities.*
- *Where the following is not already the case, jurisdiction over rules and regulations governing commercial aquaculture of Acipenseriformes should be given to state and provincial fisheries agencies, rather than agriculture or other departments, throughout the United States and Canada. This would recognize that, unlike other fish*

that may be commercially farmed, wild populations of native paddlefish and sturgeon face unique conservation challenges, and the production of caviar from such operations is closely linked to production from commercial fisheries. Providing authority over commercial aquaculture to the fisheries agencies that are already the primary public stewards of wild sturgeon and paddlefish populations would also better centralize information on catch and production levels in individual jurisdictions, and thereby facilitate efforts to detect and eliminate illegal laundering of wild-caught roe through commercial aquaculture operations.

- *Fisheries authorities should develop a clear set of guidelines regarding the placement and operational requirements for aquaculture facilities to prevent any escape of cultured fish that could lead to transmission of non-native diseases, hybridization, or the genetic dilution of wild populations. Past instances of unintentional or intentional release of cultured sturgeon (e.g., the case of white sturgeon found in Georgia rivers) demonstrate that the industry needs to be carefully regulated to avoid any such future incidents.*
- *Fisheries authorities should also consider the pros and cons of proposals such as reservoir ranching in closed water bodies as a way to increase the production of commercially valuable species without impacting wild populations. Such ideas may or may not prove ecologically and economically feasible and sustainable, but given the likely increase in demand for caviar from North American species, innovative ideas to meet market demands need to be explored.*

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TRAFFIC Telephone Survey of State and Provincial Fisheries and Wildlife Agencies, 2002–2003

In late 2002 and early 2003, TRAFFIC contacted the following agencies and individuals by telephone to inquire about the status of captive propagation, stocking, and commercial aquaculture pertaining to North American paddlefish and sturgeon in the United States and Canada.

Alabama:	Stan Cook, Alabama Department of Conservation and Natural Resources
Arkansas:	Bill Posey, Arkansas Game and Fish Commission
Georgia:	Ted Hendrickx, Georgia Department of Natural Resources
Illinois:	Steve Shults, Illinois Department of Natural Resources
Indiana:	Brant Fisher, Indiana Department of Natural Resources
Iowa:	John Pitlo, Iowa Department of Natural Resources
Kansas:	Tom Mosher, Kansas Department of Wildlife and Parks
Kentucky:	Doug Henley, Kentucky Department of Fish and Wildlife Resources
Louisiana:	Bobby Reed, Louisiana Department of Wildlife and Fisheries
Michigan:	Gary Whelan, Michigan Department of Natural Resources
Minnesota:	Linda Erickson-Eastwood, Minnesota Department of Natural Resources
Mississippi:	Dennis Riecke, Mississippi Department of Wildlife, Fisheries and parks
Missouri:	Vince Travnichek, Missouri Department of Conservation
Montana:	Ken MacDonald, Montana Department of Fish, Wildlife and Parks
Nebraska:	Gerald Mestl, Nebraska Game and Parks Commission
North Dakota:	Greg Power, North Dakota Game and Fish Department
Ohio:	Randy Sanders, Ohio Department of Natural Resources
Oklahoma:	Brent Bristow, USFWS
South Dakota:	Cliff Stone, South Dakota Department of Game, Fish and Parks
Tennessee:	Rob Todd, Tennessee Wildlife Resources Agency
Texas:	Bob Betsill, Texas Department of Wildlife and Parks
West Virginia:	Chris O'Bara, West Virginia Division of Natural Resources
Wisconsin:	Ron Bruch, Wisconsin Department of Natural Resources
Wyoming:	Steve Yekel, Wyoming Game and Fish Department
Alberta:	Jim Wagner, Alberta Ministry of Sustainable Resource Development
Manitoba:	Barbara Scaife, Manitoba Conservation
Ontario:	Mark Muschett and Scott Watson, Ontario Ministry of Natural Resources
Quebec:	Eric Gilbert, Office of the Commissioner for Aquaculture Development, Fisheries & Oceans Canada; Daniel Hatin, Societe de la Faune et des Parcs du Quebec
Saskatchewan:	Jerry Banks, Saskatchewan Department of Environment