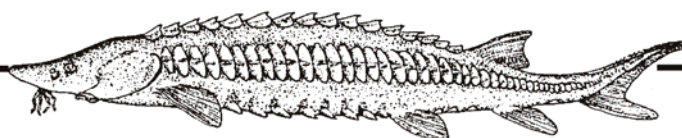


FRAMEWORK

FOR THE **M**ANAGEMENT
AND **C**ONSERVATION OF
PADDLEFISH AND **S**TURGEON
SPECIES IN
THE **U**NITED **S**TATES



**FRAMEWORK
FOR THE
MANAGEMENT AND CONSERVATION
OF
PADDLEFISH AND STURGEON SPECIES
IN
THE UNITED STATES**

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the National Paddlefish and Sturgeon
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## PREFACE

Paddlefish and sturgeon are the most primitive bony fishes in North America. Some species are anadromous while others complete their life cycles in large rivers, reservoirs, or lakes. The paddlefish and most sturgeon species are commercially important sources of flesh and caviar. Some species also support recreational or subsistence fisheries and are of interest to both public and private aquaculturists. As a group, paddlefish and sturgeon occur in 41 states within the continental United States. Most species are currently the focus of multi-state or national recovery efforts.

Efforts to manage, conserve, and restore paddlefish and sturgeon populations are currently underway by the U.S. Fish and Wildlife Service (Service), individual States, Tribes, interstate fisheries commissions, a number of other Federal and public agencies, universities, and private aquaculture interests. Regardless of species, all ongoing efforts are confronted with similar problems. These include: lack of sufficient information on stock size, movements and distribution, population genetics, harvest and contaminant effects, essential habitat requirements, and the poorly defined role of artificial culture and stocking in population recovery. Management of paddlefish and sturgeon stocks is further complicated by conflicting regulations and illegal fisheries, and the lack of a mechanism for rapid and effective dissemination of information between agencies and groups working on these species.

Paddlefish and sturgeon are long-lived and take a relatively long time (10-20 years in some cases) to reach sexual maturation. They have widespread natural ranges. Consequently, most paddlefish and sturgeon species are interjurisdictional. Stock enhancement and restoration, where necessary, will therefore take many years and will benefit from partnerships and national leadership.

The purpose of this document is to propose a framework for the development of these partnerships and to define the Service's role in the management and conservation of the Nation's paddlefish and sturgeon resources. This document addresses the need for a national perspective for these species, identifies common problems, and recommends methods and measures to address these problems.

The Service's **FISHERIES' VISION FOR THE FUTURE** defines the responsibilities and role of the agency in the conservation of the Nation's fisheries. Under the **Vision**, the primary focus of the Service's Fisheries Program is on (1) interjurisdictional and depleted species and threats to these species including the habitats that support them; (2) fishery resources on Service,

Tribal, and other Federal lands; and (3) those species defined by mitigation and legal mandates.

The **Vision's** goal and strategies affirm the Service's commitment to meet the challenges and opportunities of the Nation's fisheries as a leader and partner to ensure the wise conservation, management, and sustainability of our country's fishery resources. However, the Service cannot manage, conserve, and restore the Nation's paddlefish and sturgeon populations alone. To be successful, this venture requires a joint effort which includes participation of all entities that are involved in the management of paddlefish and sturgeon populations in the United States. We must work together, and, where necessary, we must develop new partnerships for more efficient and effective use of our resources.

The impetus for development of this framework document was derived from the participants at a national workshop on paddlefish and sturgeon, convened in Atlanta, Georgia, in January 1992. Steering committee membership included representatives of the Service, several States, the private aquaculture community, and academia.

## INTRODUCTION

Although populations are sparse, paddlefish and sturgeon species inhabit many major freshwater and nearshore marine environments in North America. Certain species often occur over a wide geographic area and in many habitats during their various life stages (Table 1<sup>a</sup>). These habitats include large rivers, lakes and impoundments, oxbow lakes, estuaries, and marine waters over the continental shelf. Some species are anadromous while others complete their life cycles in inland waters.

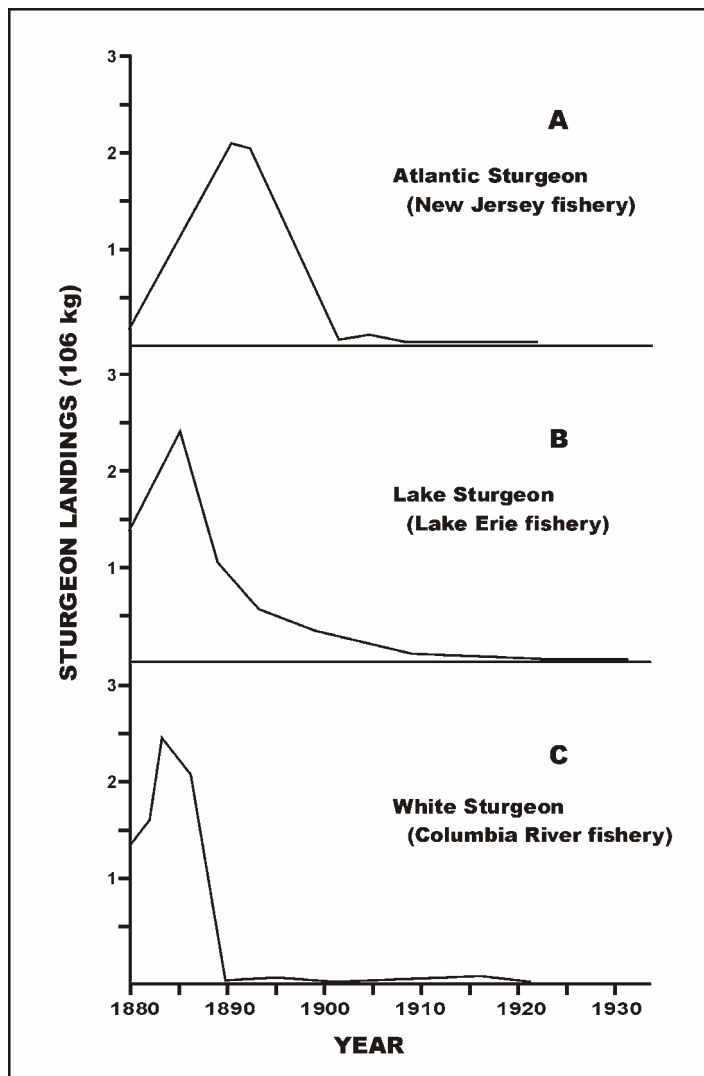
Table 1<sup>a</sup>  
Geographical distribution and general habitat of North American paddlefish and sturgeons

| Species                       | Common Name         | Geographical                                                                                                                   | Distribution Habitat                                                              |
|-------------------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| <i>Acipenser brevirostrum</i> | Shortnose sturgeon  | Atlantic coast from St. John River, New Brunswick, Canada, to St. Johns River, east coast of Florida                           | Anadromous; large coastal rivers                                                  |
| <i>fulvescens</i>             | Lake sturgeon       | Mississippi River, the Great Lakes, and the Hudson Bay drainage basins                                                         | Freshwater; lakes and large rivers                                                |
| <i>medirostris</i>            | Green sturgeon      | Pacific coast from Gulf of Alaska south to north Baja, California, especially the Columbia River                               | Anadromous; primarily marine                                                      |
| <i>oxyrinchus desotoi</i>     | Gulf sturgeon       | Gulf coast from the Mississippi River in the west to Florida Bay in the east                                                   | Anadromous; primarily freshwater and estuarine                                    |
| <i>oxyrinchus oxyrinchus</i>  | Atlantic sturgeon   | Atlantic coast from Labrador through Gulf of Mexico                                                                            | Anadromous; primarily estuarine to northern coast of South America                |
| <i>transmontanus</i>          | White sturgeon      | Pacific coast from Gulf of Alaska south to north Baja, California, especially Columbia River and Sacramento-San Joaquin system | Anadromous or semi-anadromous; large flowing rivers                               |
| <i>Scaphirhynchus albus</i>   | Pallid sturgeon     | Mississippi River from Illinois south to Louisiana; Missouri River from Montana to Missouri                                    | Freshwater; large turbid flowing rivers                                           |
| <i>platorhynchus</i>          | Shovelnose sturgeon | Ohio, Mississippi, and Missouri rivers; Rio Grande River in Texas and New Mexico                                               | Freshwater; large turbid flowing rivers                                           |
| <i>suttkusi</i>               | Alabama sturgeon    | Mobile River system of Alabama and Mississippi                                                                                 | Freshwater; rivers with moderate to swift currents                                |
| <i>Polyodon spathula</i>      | Paddlefish          | Mississippi River system, Mobile Bay drainage, Alabama River west to east Texas                                                | Freshwater; backwaters, sluggish pools, bayous, oxbows of large rivers, and lakes |

<sup>a</sup>Table 1. Geographic distribution and general habitat of North American paddlefish and sturgeons. (Modified from T.I.J. Smith, NOAA Tech. RPT. NMFS 85, March 1990)

Historically, with the exception of the pallid sturgeon, all species were commercially important in North America. During the

peak of the sturgeon fishery (1885-1895) an estimated 11.4 million kg of sturgeon were harvested annually from United States waters. By the late 1890's, however, overfishing, habitat losses due to construction of dams, and watershed development and alteration had caused a severe decline in stocks (Figure 1). For example, combined landings of Atlantic, Gulf, and shortnose sturgeon decreased from 3,000,000 kg annually in the late 1880's to below 500,000 kg by 1902, and to less than 50,000 kg for most of the period from 1921 to the present: a 98% decline.



**Figure 1.** Commercial exploitation of various stocks of sturgeon from 1880-1930. (From T.I.J. Smith, NOAA Tech. RPT. NMFS 85 March 1990).

Even though the abundance of paddlefish and sturgeon has been reduced over much of their current range, there is evidence that these fish respond well to appropriate management. Several sturgeons (e.g. Atlantic, Gulf, shortnose, and pallid) are currently the focus of interagency recovery or management plans; however, often there exists a lack of coordination and information sharing among those working on various species.

Three sturgeons (shortnose, pallid, and Gulf) have already been listed as endangered or threatened under the Endangered Species Act, and three other species -- the white sturgeon in the upper Columbia river drainage, the Alabama sturgeon, and the paddlefish -- have been proposed for listing. Continued habitat destruction and alteration, coupled with illegal harvest, may impede cost-effective restoration or survival of several of these species (e.g., pallid sturgeon and paddlefish).

Problems that affect paddlefish and sturgeon management are generally similar. This document offers a series of recommendations and strategies to address those common problems, and is the first step in developing a national perspective for management and conservation of the Nation's paddlefish and sturgeon species.

There is general agreement among the states, the Service, academia, and private aquaculturists that without a concerted, well coordinated national effort with participation by all interested parties, paddlefish and sturgeon populations in the United States will continue to decline, and there will be further endangered and threatened species listings and fishery restrictions.

## **PROBLEMS/RECOMMENDATIONS/STRATEGIES**

**Problem 1:** There is a need to develop a coordinated national strategy for the management<sup>a</sup> of paddlefish and sturgeon resources to protect the remaining stocks.

**Recommendation 1.1:** The Service will assume a national leadership role and facilitate and coordinate development of an administrative and management framework among Federal, State, Tribal, university, and private sector entities that have an interest in the management of paddlefish and sturgeon.

**Strategy 1.1.1:** Identify organizations with interjurisdictional coordination and communication responsibilities, and evaluate their role in paddlefish and sturgeon management

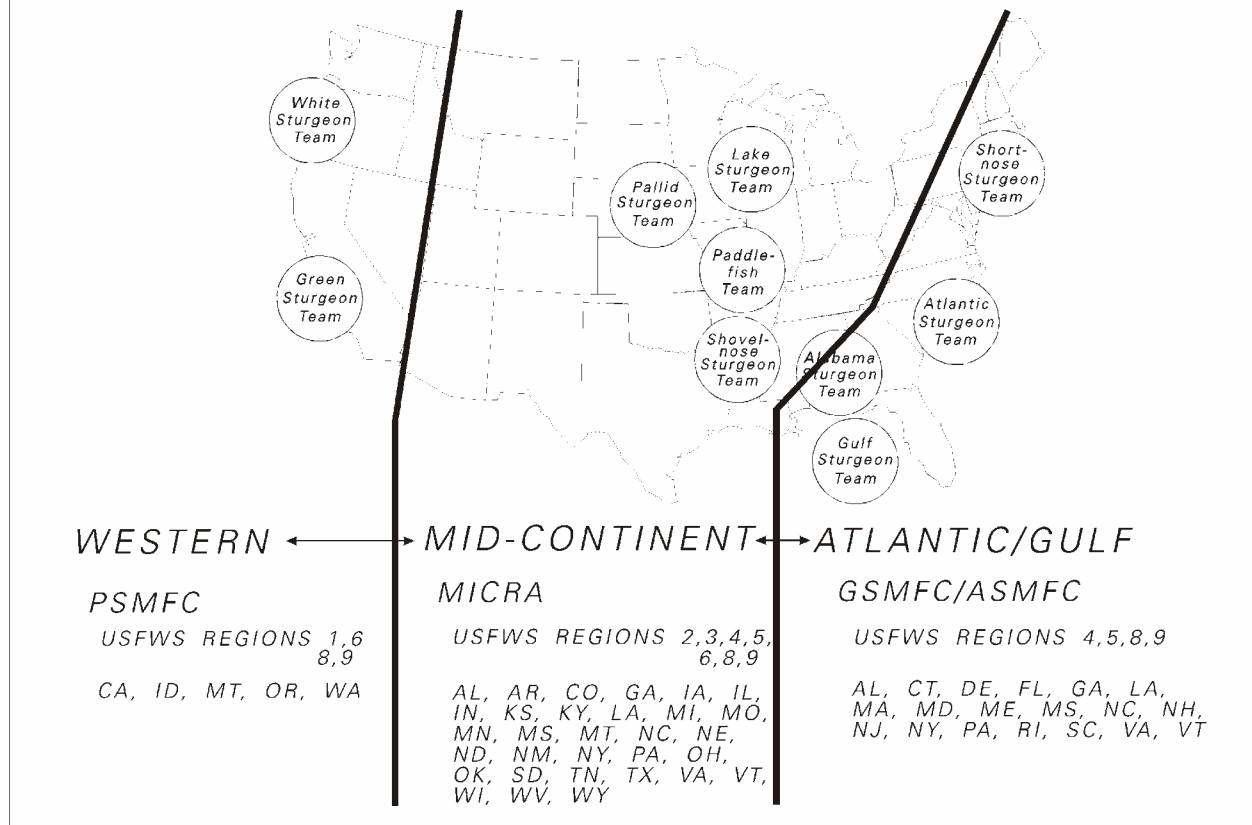
**Strategy 1.1.2:** Identify administrative networks necessary to facilitate paddlefish and sturgeon management.

**Strategy 1.1.3:** Where necessary, create new partnerships and develop formal agreements among Federal, State, Tribal, private, and International entities interested in paddlefish and sturgeon management.

**Rationale:** There is currently no nationwide mechanism to maintain coordination and communication among administrators, resource managers, hatchery managers, and researchers who are involved in the management of paddlefish and sturgeon species. Because many paddlefish and sturgeon populations are interjurisdictional and anadromous, and several species are listed as threatened or endangered, the Service has, as stated in the **FISHERIES' VISION FOR THE FUTURE**, a responsibility for their protection and maintenance. The Service should therefore work with the States, Tribes, and other public and private management entities to coordinate the creation of a scientific and administrative network to facilitate communication and coordination among paddlefish and sturgeon interests nationwide. An example of a possible network is provided in Figure 2.

<sup>a</sup>The word *management* throughout this document is defined to include, but not limited to, traditional management strategies such as culture, enforcement, harvest management, habitat management, and research.

# NATIONAL PADDLEFISH/STURGEON COORDINATION NETWORK



**Figure 2.** Example of a possible national network for cross communication and coordination between paddlefish and sturgeon interests.

**Recommendation 1.2:** The Service, states, Tribes, and other Federal, state, and private entities interested in the management and conservation of paddlefish and sturgeon will establish and maintain coordination and communication to provide support for management activities and to assist in the development of funding initiatives.

**Strategy 1.2.1:** Develop and maintain a communication network (e.g., newsletters, workshops, symposia) among Federal and state agencies, Tribes, and private entities involved in paddlefish and sturgeon management.

**Strategy 1.2.2:** Create a focal point to identify and coordinate funding initiatives to support paddlefish and sturgeon management in the United States.

**Rationale:** Improved communication among management entities and private interests working on paddlefish and sturgeon will enhance dissemination of information with potential application to species of concern. Interagency and cooperative (State-Federal-Tribal-private) management programs on paddlefish and sturgeon will likely generate a broader interest in development of financial support than will individual efforts.

**Recommendation 1.3:** The Service will work with the states and other management entities to develop and implement interjurisdictional management and recovery plans for paddlefish and sturgeon in the United States.

**Strategy 1.3.1:** Maintain central repositories for information and plans for paddlefish and sturgeon management.

**Strategy 1.3.2:** Prepare and implement interjurisdictional management and recovery plans as warranted.

**Strategy 1.3.3:** Evaluate the status of paddlefish and sturgeon management activities and provide annual management recommendations to management entities.

**Rationale:** The Service has a national responsibility to ensure the conservation, maintenance, and recovery of threatened and endangered species, and to support interjurisdictional fishery management efforts. Populations of paddlefish and several sturgeon species have been drastically reduced on a national scale. The Service should maintain central repositories of information on management plans for paddlefish and sturgeon species; prepare, implement, and encourage the development of management and recovery plans as warranted; and prepare periodic reports which summarize the status of paddlefish and sturgeon management activities.

**Problem 2:** There is a general lack of understanding and awareness by the public of the ecological and economic importance of paddlefish and sturgeon species, and of the environmental and human-related impacts that threaten the welfare and continued existence of many paddlefish and sturgeon populations.

**Recommendation 2.1:** The Service, States, Tribal, and other public and private entities that have an interest in paddlefish and sturgeon will establish coordinated mechanisms to increase the level of public awareness of the diminishing stocks of paddlefish and sturgeon.

**Strategy 2.1.1:** Develop informational materials on paddlefish and sturgeon for public dissemination (e.g., brochures, videos, displays).

**Strategy 2.1.2:** Report on paddlefish and sturgeon management activities in news releases and presentations to professional, student, civic, legislative, fishing, and other interest groups.

**Rationale:** Public appreciation and understanding of these species is necessary to gain support for restoration programs. The Service and other interested entities can make a major contribution to the welfare of these species by elevating their public image and the public's understanding of their habitat requirements.

**Problem 3: Life history, population characteristics, and habitat requirements of paddlefish and sturgeon are poorly understood.**

**Recommendation 3.1:** The Service will work with other management entities to identify, participate in, and support studies on: life history and population characteristics; identification of essential habitats; contaminants; and identification of suitable water quality and quantity to ensure survival and to enhance populations of paddlefish and sturgeon.

**Strategy 3.1.1:** Under the auspices of interagency networks described in Strategy 1.1.3, identify critical life history and habitat information needs for paddlefish and sturgeon resources and develop necessary study plans that include assessment of population status.

**Strategy 3.1.2:** Management entities should dedicate the resources necessary to implement the coordinated, long-term interjurisdictional efforts outlined in Strategy 3.1.1.

**Strategy 3.1.3:** Encourage cooperative studies with academic institutions and the private sector to address specific research or informational needs related to paddlefish and sturgeon management.

**Rationale:** Perpetuation of self-sustaining stocks of paddlefish and sturgeon requires a comprehensive understanding of their biology, population dynamics, habitat needs, water quality requirements, fisheries interactions, and the short and long-term effects of contaminants and other human-induced impacts. Due to their interjurisdictional nature, the lack of awareness by the public and many resource agencies of their economic and environmental value, and the resulting scarcity of dedicated funding, there has been little research focused on these species. The Service should encourage and work with the States and other management entities to conduct and support studies to identify biological and environmental factors that affect the survival of paddlefish and sturgeon.

**Problem 4:** Culture and stocking of paddlefish and sturgeon by Federal, State, and private interests are largely uncoordinated. This can lead to problems involving hybridization, genetic integrity, fish health, and ecological issues detrimental to perpetuation of native stocks of paddlefish and sturgeon.

**Recommendation 4.1.:** Service, State, and private paddlefish and sturgeon hatchery operations and aquaculture development and management programs will culture and stock fish in a manner that is compatible with the preservation and restoration of native stocks in accordance with approved management plans.

**Strategy 4.1.1:** Assess genetic variability in populations of paddlefish and sturgeon to determine the isolation and mixing of stocks.

**Strategy 4.1.2:** Ensure that stocking programs are conducted using ecologically compatible fish.

**Rationale:** Many Service, State, and private entities are, or will be, involved in the culture and stocking of paddlefish and sturgeon. Individual strains or sub-populations of target species may exhibit unique adaptations to their specific habitats (e.g., anadromous homing to natal rivers). To ensure that natural genetic and other population characteristic structure and variability are maintained, the Service, States, and other entities involved in the culture and stocking of paddlefish and sturgeon should conduct their programs in a manner that avoids altering natural populations.

**Recommendation 4.2:** The Service, States, and other management entities will identify and support coordinated investigations of paddlefish and sturgeon to better understand and document culture techniques, chemical and drug needs, broodstock management, spawning techniques, disease problems, feeds and feeding, and methods to control bird, mammal, and reptile depredation.

**Strategy 4.2.1:** Develop cooperative working relationships to collect paddlefish and sturgeon broodfish and to improve capture, hauling, and holding techniques, in accordance with approved management plans.

**Strategy 4.2.2:** Support basic research on cultural efforts on sperm preservation, spawning techniques, incubation and rearing, drug and chemical needs and clearance requirements, broodstock maintenance, disease assessment and treatment, and sturgeon.

**Strategy 4.2.3:** As information becomes available, identify best cultural practices for paddlefish and sturgeon and develop and disseminate hatchery guidelines.

**Rationale:** Except for commercial aquaculture of white sturgeon in California, culture of paddlefish and sturgeon is largely fragmented and uncoordinated. Though many entities are involved, specific techniques for broodstock collection and management, spawning, egg incubation, rearing, disease assessment, feeds and nutrition, and drug and chemical needs are not fully described or are not readily available to all users. With the recent increase in interest at the national and State levels in paddlefish and sturgeon, and to reduce needless repetitive efforts, the Service, States, and other management entities should identify and support a national mechanism for the coordination of technological development and research activities for these species.

**Recommendation 4.3:** Service, State, and other management entities will conduct and support comprehensive evaluation of the need for and the effectiveness of supplemental stocking in fishery restoration, mitigation, and enhancement.

**Strategy 4.3.1:** Develop criteria, based on biological, political, social, and economic considerations, to evaluate the need for and the effectiveness of stocking efforts.

**Strategy 4.3.2:** Develop a standard benefit-risk assessment procedure for stocking paddlefish and sturgeon, and develop standards for disposal of all fish which have been produced beyond the approved stocking request.

**Strategy 4.3.3:** Conduct and support research to identify suitable fish sizes, sites and times of year for stocking paddlefish and sturgeon, as well as suitable handling and hauling procedures.

**Strategy 4.3.4:** Support development of cost effective long-term tagging techniques and recovery methods, and encourage that all hatchery released paddlefish and sturgeon are tagged or marked.

**Strategy 4.3.5:** Support the establishment and maintenance of regional tag/mark clearinghouses and data base management functions to control and assign tag types and numbers to avoid repetition and confusion, and to consolidate and evaluate tagging and tag return information.

**Rationale:** The impact of the release of large numbers of paddlefish and sturgeon on wild populations must be evaluated. These stockings should not be viewed as adequate replacement for natural production lost to habitat alteration or overfishing. Instead, artificial propagation should be considered to supplement diminished wild populations, to replace lost stocks when destructive factors are eliminated, or to maintain populations where natural reproduction is

lacking because of loss of suitable spawning habitat. Because of the potentially high costs and requisite dedication of personnel and facilities required for stocking programs, beneficial results of hatchery culture and stocking must be demonstrated in terms of survival, growth, and relative contribution to existing populations. To prevent negative impacts on wild populations, standards should be developed for the beneficial use of paddlefish and sturgeon which have been produced beyond approved management needs.

**Problem 5: Habitat alteration and destruction are negatively impacting many populations of paddlefish and sturgeon.**

**Recommendation 5.1:** The Service, States, and other management entities will use all existing authorities to ensure that habitat essential to these species is not destroyed or degraded, and that degraded habitats are restored.

**Strategy 5.1.1:** Ensure that all water-dependent projects are fully evaluated for both site specific and systemic impacts on paddlefish and sturgeon, and, where necessary, appropriate mitigation is provided.

**Strategy 5.1.2:** Strengthen regulations and laws where necessary to protect essential paddlefish and sturgeon habitat. As information derived from research conducted pursuant to Recommendation 3.1 is forthcoming, incorporate increased knowledge of life histories, population characteristics, and their relationships to habitat requirements into existing and new regulations.

**Strategy 5.1.3:** Initiate cooperative interagency efforts to ameliorate or otherwise reverse the impacts of previous projects through habitat restoration.

**Strategy 5.1.4:** Initiate efforts to use the existing authority of the National Wildlife Refuge System to develop habitat protection and restoration schemes for paddlefish and sturgeon species.

**Rationale:** Habitat alteration and destruction have drastically effected paddlefish and sturgeon populations. Many of the water-dependent projects that impact these species have been developed and implemented without providing for appropriate mitigation for paddlefish and sturgeon habitat loss. If this trend is not reversed many more of these species will become threatened, endangered, or extirpated.

**Problem 6: Overfishing, illegal take, and commerce are reducing many populations of paddlefish and sturgeon.**

**Recommendation 6.1:** The Service will provide the leadership and support necessary to encourage States that share specific

interjurisdictional stocks of paddlefish and sturgeon to standardize fishing regulations for these species.

**Strategy 6.1.1:** Encourage and support multi-agency assessment of interjurisdictional paddlefish and sturgeon stocks and fisheries to ensure maintenance and preservation of viable populations.

**Strategy 6.1.2:** Support establishment and maintenance of interjurisdictional fisheries management groups (e.g., MICRA, UMRCC, and MRNRC) to continuously review and recommend standardization of fishing regulations.

**Strategy 6.1.3:** As information derived from research conducted pursuant to Recommendation 3.1 is forthcoming, incorporate increased knowledge of life histories, population characteristics, and their relationships to interjurisdictional management strategies and plans into existing and new official positions of interjurisdictional groups.

**Rationale:** Because most paddlefish and sturgeon species typically make extensive migrations within their respective ranges, they are exposed to harvest in many jurisdictions. Anadromous sturgeon species of unspecific origin may be legally taken in indiscriminate coastal interception fisheries, and most of the major spawning rivers and lakes used by paddlefish and sturgeon either have shared boundaries or course through two or more states. Where commercial or sport fisheries exist on widely ranging stocks, effective population management is hindered by a lack of coordinated regulations.

**Recommendation 6.2:** The Service, States, and other management entities will support and enforce laws pertaining to illegal take, transport, and commerce of paddlefish and sturgeon and their products.

**Strategy 6.2.1:** Enhance existing cooperative law enforcement efforts with States and other authorities to eliminate illegal commerce in paddlefish and sturgeon species and their products.

**Strategy 6.2.2:** Enhance awareness of cooperative law enforcement agencies and other authorities of paddlefish and sturgeon enforcement issues and tactics.

**Strategy 6.2.3:** Evaluate existing laws and authorities and strengthen and clarify them where necessary.

**Strategy 6.2.4:** In concert with private industry, develop and implement a practical system for marking and tracking

the flow of domestically reared paddlefish and sturgeon species and their products.

**Rationale:** Due to high demand and financial incentives, many paddlefish and sturgeon stocks are exposed to illegal harvest for black market trade. As more restrictive regulations are placed on legal fisheries, unlawful harvest may increase. Resource management and population recovery are severely hampered by illegal harvest and must, therefore, be investigated.

## **APPENDICES**

## **APPENDIX I**

### **SPECIES ACCOUNTS**

#### **Shortnose Sturgeon: *Acipenser brevirostrum* (LeSueur)**

The shortnose sturgeon is restricted to the east coast of North America with a geographic distribution from the St. John River, New Brunswick, to the Indian River, Florida. Although landlocked populations occur in the Holyoke Pool on the Connecticut River and perhaps in the Lake Marion-Moultrie system in South Carolina, the species is generally considered to be anadromous. Abundance of adults is typically greatest in the estuarine portions of river systems; all captures at sea have occurred within a few kilometers of land. In general, shortnose sturgeon northern populations have a life span similar to other *Acipenser* spp., but individuals from southern populations may be shorter-lived. The oldest female and male shortnose, both collected from the St. John River, Canada, were 67 and 32 years of age, respectively. The maximum recorded size for this species is a 1.43 m female that weighed 23.6 kg. The largest male was 1.08 m and weighed 9.5 kg.

When shortnose sturgeon attain adult size of 46-50 cm most begin displaying migratory behavior, traveling upstream in spring and then downriver after spawning. In some large rivers however, adults may overwinter in deep waters adjacent to spawning grounds. Arrival at spawning areas coincides with water temperatures of 8-10°C, and spawning throughout most of the species' range occurs at 9-12°C. Juvenile shortnose may remain in tidal fresh and brackish water of their natal rivers for 2-8 years depending upon geographic location. Males mature as early as 2-3 years in Georgia and as late as 10-11 years in New Brunswick. Females exhibit a similar trend, maturing at ages 4-6 years in southern waters and 12-15 years in Canada. Length at maturity is similar throughout the species' range, occurring at 46-50 cm for both sexes. Though annual spawning has been documented for a few fish in South Carolina, spawning periodicity is probably 2-4 years depending in part on environmental conditions.

Historically, shortnose sturgeon were harvested commercially with Atlantic sturgeon for flesh and caviar, but no species designations were recorded in the landings data. Incidental fishing mortality, principally in shad gill nets, has been speculated as a major reason for the disappearance of this species from shallow estuaries of the Chesapeake Bay. A few shortnose are also taken incidentally by nearshore ocean trawlers. However, the main reason for the current low abundance

of this species is loss of habitat due to water pollution and dams, and possibly also due to a decrease in the volume of artesian-fed oversummering sites in the rivers of the deep south. The shortnose sturgeon is listed as an endangered species in accordance with provisions of the Endangered Species Act of 1973, as amended. All taking of this species is prohibited in waters of the United States. An interagency committee (Shortnose Sturgeon Recovery Team) has been established to assess the status of the population(s) and to develop a recovery plan.

### **Lake Sturgeon: *Acipenser fulvescens* (Rafinesque)**

Lake sturgeon are widely distributed in North America and are found in three major drainages: the Mississippi River, the Great Lakes, and the Hudson Bay. This large, primitive, freshwater fish occurs in greatest abundance in large lakes and rivers of the Great Lakes region of the United States and Canada, but most of its range in the United States is in the Mississippi River Basin from the upper Mississippi River and its major tributaries to the southern border of Arkansas.

The lake sturgeon is a freshwater species, but in eastern Canada, they may occasionally be found in brackish water. Lake sturgeon are shallow water fish, seldom found in waters exceeding 6 m. Benthic macroinvertebrates, especially insect larvae, are the primary diet of lake sturgeon.

Lake sturgeon spawn in late spring either within the lakes they inhabit, or, as is more often the case, after ascending small streams that feed into the lake. Large, adhesive eggs are deposited on the shallow, gravelly riffles of streams or the rocky shoals of lakes. Lake sturgeon grow very slowly. Four or five years are usually required to reach a length of 51 cm and a weight of 0.5 kg. Females usually reach sexual maturity in 20-24 years while males may mature in 15-17 years. Individuals 40 years of age are not uncommon. The maximum reported age is 152 years. The largest lake sturgeon ever verified weighed 140.6 kg and was captured in Lake Michigan in 1943.

Lake sturgeon were an important commercial fish in the upper Mississippi River and the Great Lakes region during the late 1800's. Most were processed as smoked sturgeon, caviar, isinglass, and fish oil. However, because of the large market for sturgeon flesh, lake sturgeon were soon overexploited. More recently, pollution and alteration of large rivers, including dam construction, channelization, and dredging, have adversely affected lake sturgeon populations. Although lake sturgeon populations have declined over much of their range, there is evidence that populations can recover when sufficient numbers of mature fish and adequate habitat are maintained. For example, the lake sturgeon population in Wisconsin's Lake Winnebago system

was stable during the 1930's and 1940's, but the population increased after property owners began rip-rapping riverbanks with large rock in the 1950's to reduce erosion. The rip-rapped shore line greatly increased the area suitable for successful spawning.

Several State agencies are currently rearing and stocking lake sturgeon fingerlings in an attempt to recover once thriving populations. Young lake sturgeon, however, are expensive to produce because they will not eat commercial diets and are fed live or frozen bloodworms or brine shrimp.

### **Green Sturgeon: *Acipenser medirostris* Ayres**

The green sturgeon is native to North America and Asia (Japan, Korea, China, and the Commonwealth of Independent States [Soviet Union]). Historically, North American populations ranged from the Gulf of Alaska to southern California. Presumed spawning populations of green sturgeon presently occur in the Fraser River, British Columbia; Rogue River, Oregon; and the Klamath, Sacramento, and Trinity Rivers in California.

When compared with the other sturgeon species, little is known about the biology of green sturgeon. In California waters, green sturgeon adult spawners migrate into freshwater in the spring, and are broadcast spawners. Klamath River adult sturgeon, presumed to be migrating to and from the ocean, are captured in the Indian gill net fishery during the spring, summer, and early fall months. In the lower Fraser River, British Columbia, adult green sturgeon appear to migrate upstream in late summer and early fall, in advance of their spring spawning. Adult green sturgeon have been observed in large deep pools during their migratory period. In the Klamath River, juvenile sturgeon have been captured in protected backwater pools and in the shallow margins of the estuary.

Juveniles may spend several years in freshwater prior to emigration to the ocean. In the Klamath River, juvenile sturgeon appear to migrate seaward at the end of their second summer. Although green sturgeon are known to migrate considerable distances in the ocean, little is known about the oceanic phase of their life history. Age and growth information is sparse and fragmented. For Klamath River green sturgeon, an average length of 1.0 m is attained in 10 years, 1.5 m by age 15, and 2.0 m by 25 years of age. The largest reported green sturgeon weighed about 159 kg and was 2.1 m in length.

Reliable information is not available on the historical abundance of green sturgeon. Presently, green sturgeon are harvested in the Sacramento River system (San Francisco and San Pablo bays), Klamath River system, the mouth of the Columbia River, and Willapa Bay and Grays Harbor, Washington. In California waters,

particularly the Klamath River basin, there are concerns that green sturgeon stocks are being over-harvested. The possibility that green sturgeon stocks migrate and mix with other populations increases these concerns. Adult green sturgeon tagged from the Sacramento River system have been recovered in Washington waters indicating that migratory stocks would be subject to harvest interception in multiple zones.

A number of Federal, State and Tribal management entities monitor West Coast sturgeon fisheries. The U.S. Fish and Wildlife Service monitors the capture of sturgeon in Native American spring and fall chinook gill net fisheries. The Fisheries Department of the Hoopa Valley Business Council monitors the sturgeon take in the Trinity River within the Hoopa Valley Indian Reservation. The Oregon Department of Fish and Wildlife conducts beach seining on the Rogue River, Oregon, which occasionally captures juvenile and adult green sturgeon. The California Department of Fish and Game, Bay-Delta Project conducts on-going biological surveys on both green and white sturgeon. The Washington Department of Fisheries and Oregon Department of Fish and Wildlife monitor the commercial and recreational catches of green sturgeon in the Columbia River. Washington Department of Fisheries has a tagging operation and monitors harvest in Willapa Bay and Grays Harbor, Washington.

### **Gulf Sturgeon: *Acipenser oxyrinchus desotoi***

The Gulf sturgeon is a subspecies of the Atlantic sturgeon. The historic range of the Gulf sturgeon includes most rivers along the Gulf coast from the Mississippi River in the west to the Suwannee River in the east, and marine waters of the central and eastern Gulf of Mexico south to Florida Bay. Gulf sturgeon are still found throughout this range, but during the past 40 years their numbers have been greatly reduced. Except for the Suwannee River, Florida, which is believed to support the healthiest population of Gulf sturgeon, the species has been greatly reduced or extirpated throughout much of its historic range.

Overexploitation, deterioration of water quality, habitat destruction, and the construction of dams that block passage to spawning grounds and summer habitat have been cited as the contributing factors in the decline.

Due to the high value of their eggs for caviar and their flesh for smoking, Gulf sturgeon were heavily fished at the turn of the century. Annual landings of over 170,000 kg were reported during the early 1900's. Since then however, populations have been in a steady decline. Harvest records show that Gulf sturgeon were commercially harvested in Florida through 1984. In 1984 Florida designated the Gulf sturgeon as a "species of special concern" and passed a law prohibiting further harvest.

Adult Gulf sturgeon range in size from 1.8 to 2.4 m with reported weights of over 225 kg. Males mature at 5 to 10 years of age and females at 8 to 12 years of age. Gulf sturgeon can live up to 70 years.

Gulf sturgeon are anadromous, spending up to 9 months a year in fresh water. Adult sturgeon usually ascend their natal rivers to spawn from February through April when water temperatures are 16-23°C. They may remain in fresh water until as late as November. Adults do not eat during their periods in freshwater and may lose 15% of their body weight. Spawning is believed to occur in areas of deep water with a rocky/sandy substrate. A large female can produce over three million eggs at each spawning. Females do not spawn every year. Gulf sturgeon two years of age and less appear to remain in riverine and estuarine areas throughout the year. Little is known of Gulf sturgeon habits and habitats in the marine environment, or the habitat occupied by early young of the year individuals.

Techniques for induced spawning were developed in 1989. Progeny are used to develop fish cultural techniques and for limited stocking.

The Gulf sturgeon was listed as a threatened species on September 30, 1991, in accordance with provisions of the Endangered Species Act of 1973, as amended.

### **Atlantic Sturgeon: *Acipenser oxyrinchus oxyrinchus* Mitchill**

The Atlantic sturgeon is an anadromous species which occurs along the Atlantic coast from Labrador to Florida. Under natural conditions, this species can grow to an advanced age and great size with the largest documented fish being a 60-year old female, 4.3 m long and weighing 368 kg, taken offshore from New Brunswick's St. John River in 1924.

Spawning migrations into coastal rivers begin as early as February in Florida and continue through June and July in the Gulf of Maine. At this time adults are highly susceptible to commercial fishing. Spawning occurs in freshwater or in slightly brackish water at temperatures of 13-18°C. Young sturgeon generally spend up to 6 years in fresh and brackish riverine habitat prior to emigration to sea. In southern latitudes, fish may mature earlier than the 6-10 years for males and 10-20 years for females recorded in the mid-Atlantic coastal areas. Spawning periodicity ranges from 2-6 years. The Atlantic sturgeon is known for its ability to make long oceanic migrations with documented movements of up to 1,450 km.

Atlantic sturgeon have a long history of commercial exploitation and were an important item of commerce to early colonists. During the 17th century sturgeon flesh, roe, oil, and isinglass were exported in large quantities to Europe. By the 1850's sturgeon flesh and roe (caviar) gained popularity in this country and large catches were recorded for several decades thereafter. This was particularly true of the Delaware River and Delaware Bay which supported over 1,000 fishermen and produced 2.27 million kg of sturgeon products in 1890. By the turn of the century the total Atlantic sturgeon harvest was reduced by over 90%. Reasons for this drastic decline were primarily overfishing, habitat degradation, and damming of spawning rivers. In the mid-1920's the center of the fishery shifted to the Carolinas, and in recent years the majority of harvest has come from New York, New Jersey, and North and South Carolina. Throughout the 1980's, Atlantic sturgeon harvest ranged between 50,000-100,000 kg annually with as much as 70% of this taken incidentally in groundfish trawls and shad gill nets. Today, fewer than 100 individuals are involved in directed fishing for this species.

Due to the decreased abundance of Atlantic sturgeon, the Atlantic States Marine Fisheries Commission (ASMFC) undertook development of a coast-wide fishery management plan for this species. The plan was approved by ASMFC in 1990 and has a goal of restoring Atlantic sturgeon to fishable abundance ([i.e., sustained harvest of 318,000 kg [700,000 lbs.] per year) throughout its range. The major management recommendation in the plan is to encourage States to control harvest in an effort to increase spawning biomass.

Based on plan recommendations, most States have either closed their sturgeon fisheries or established a 2.13 m (7-ft) minimum size limit to allow females to spawn at least once. However, it is not known if this alone will result in restoration of the various stocks. Shrimp trawl and shad gill net bycatch remain known but unquantified sources of fishing mortality. It is also probable that the juvenile and a significant portion of the adult segments of populations inhabiting the rivers of the deep south depend on the existence of artesian-supplied oversummer refuges for their survival. The extent and relative importance of this habitat utilization pattern remains unquantified as well.

### **White Sturgeon: *Acipenser transmontanus* Richardson**

Historically, white sturgeon may have ranged along the Pacific coast of North America from the Aleutian Islands of Alaska to Ensenada, Mexico. They are found in marine, brackish, and freshwater. However, present-day spawning populations are known only from the Sacramento/San Joaquin River Systems (California),

the Columbia River Basin, and the Fraser River (British Columbia).

White sturgeon males may mature at 15 years of age, while females mature at 20 to 24 years of age. Adult sturgeon usually ascend their natal rivers in the spring, and spawn from mid-April through July. White sturgeon in the Columbia River spawn at temperatures from 12 to 20°C. Recent studies have shown that white sturgeon spawning in the Columbia is positively related to water discharge (and subsequent velocity). (In the Columbia River downstream from McNary Dam from 1987 through 1991, white sturgeon spawned exclusively in the high velocity [mean col. velocity 0.8 to >3 m/s] tailwaters of Bonneville, The Dalles, John Day, and McNary dams, in the furthest upstream 3 km of each impoundment.) The amount of spawning in the Columbia River is considerably lower during drought conditions than during average water years.

White sturgeon are broadcast spawners. The semi-buoyant, adhesive eggs may drift considerable distances downstream prior to sinking and adhering to substrates. Adult fish do not spawn every year; there may be several years between spawnings.

Tagging studies indicate that adult white sturgeon have been known to migrate over 1,000 km, but most tags were recovered in the same system in which they were released. Movements within the system, however, are often extensive. The white sturgeon is capable of completing its life cycle in freshwater.

Although white sturgeon grow slowly (Columbia River fish attain 0.9 m in 8-9 years), this species is the largest North American freshwater fish, with specimens reported at over 6 m in length, and weighing more than 800 kg. The largest white sturgeon captured in recent times, however, was 3.2 m long, and 82 years of age. Oregon Department of Fish and Wildlife researchers have reliably aged a female white sturgeon to be 104 years of age. She was taken by setline in July 1991, weighed 101 kg and was 2.6 m long.

White sturgeon are opportunistic bottom feeders. Juveniles feed primarily on mysid shrimp, amphipods, or molluscs. Larger fish eat crustaceans, molluscs, and fish including lamprey, smelt, anchovies, and salmonids.

In the Columbia River, adult white sturgeon are known to frequent deep pools during the winter and shallower waters in the summer months. Adult sturgeon migrate seasonally in the Columbia River below the first dam. Juveniles are known to inhabit various habitats.

White sturgeon have historically been over-exploited and, except for some populations that have been restored to harvestable numbers under recent management practices, most populations are not stable. The state of Idaho and Province of British Columbia

have terminated harvest of this species, and the state of Montana has listed white sturgeon as a species of special concern since the early 1980's.

Resource agencies in the states of Idaho, Montana, Oregon, and Washington, as well as Federal resource agencies such as the National Marine Fisheries Service and the U.S Fish and wildlife Service, and the Kootenai Tribe of Idaho, are involved in efforts to reestablish and enhance white sturgeon populations. The Oregon Department of Fish and Wildlife, and Washington Department of Fisheries monitor the recreational, Native American, and commercial fisheries of white and green sturgeon in the lower Columbia River, where illegal harvest of large, oversize (greater than 2.8 m) mature white sturgeon continues to be a problem. The U.S. Fish and wildlife Service monitors the take of white and green sturgeon in the Klamath River gill net fishery; white sturgeon and green sturgeon, however, constitute a very small percentage of the total fish harvest in the Klamath.

In recent years, primarily due to research done at the University of California-Davis on sturgeon cultural technology, there has been an increase in interest in white sturgeon by the private aquaculture community in California and other parts of the country. The commercial potential for this species and the resulting potential for negative impacts on other native sturgeon populations are of concern to a number of resource agencies and researchers throughout the country.

#### **Pallid Sturgeon: *Scaphirhynchus albus* (Forbes and Richardson)**

The pallid sturgeon was not described as a species until 1905 and remains one of the least known of the large, freshwater fishes. The original distribution of the pallid sturgeon was probably in the Yellowstone River from the confluence of the Bighorn River downstream to the confluence with the Missouri River, in the Missouri River from Great Falls, Montana, downstream to the confluence with the Mississippi River, and in the Mississippi River from the confluence with the Missouri River to the Gulf of Mexico. The one or two early records of pallid sturgeon from the Mississippi River above the confluence of the Missouri River are likely the result of strays because prior to construction of navigational features the upper Mississippi River probably did not provide the preferred turbidity and temperature range of the species.

The historical abundance of pallid sturgeon is poorly known, but available information suggests the species was always rare. For example, in the early 1900'S, pallid sturgeon were reported to comprise only 1 in 500 of river sturgeon captured in the Mississippi River at Grafton, Illinois. However, since the development of dams and reservoirs on the Missouri River, the

species has declined even further. There are now only remnant, small populations of pallid sturgeon remaining in each of the reservoir complexes in the Dakotas, and remaining riverine habitat between the dams apparently does not meet the requirements of the species because successful reproduction has not been documented. It is also likely that the forage base once used by pallid sturgeon has been greatly altered, thus affecting growth and reproduction. The largest remaining populations of pallid sturgeon appear to be in the upper Missouri River above Ft. Peck Reservoir in Montana, in the Missouri and Yellowstone rivers above Garrison Reservoir in North Dakota and Montana, respectively, in the Mississippi River below St. Louis, Missouri, to the Old River Control structure in Louisiana, and below the Old River control structure in the Atchafalaya and Red rivers of Louisiana.

It is doubtful that any natural reproduction has occurred on the upper Missouri River during the last decade because the youngest pallid sturgeon captured from this region in recent years was age 10. This fish was captured in the Missouri River in Nebraska in 1988. Recent pallid sturgeon captures in Louisiana indicate recent reproduction from the lower basin, however. In October 1992, while monitoring catches of commercial fishermen below the Old River control structure at the headwaters of the Atchafalaya River swamp, Louisiana Department of Wildlife and Fisheries captured two small pallid sturgeon. They were 61 and 66 cm in length, respectively. The smallest of the two pallids weighed approximately 1.0 kg in weight, thus being the smallest pallid sturgeon capture on record. Both pallids were believed to be less than age 3.

Because pallid sturgeon are so rare, little is known about their life requirements. They are known to prefer large, turbid, free-flowing river habitat with rocky substrate. Pallid sturgeon are well adapted to life on the bottom and inhabit areas of swifter water than do the smaller shovelnose sturgeon. The primary forage base for adult pallid sturgeon prior to extensive modifications of riverine habitat is assumed to be flathead chubs, plains minnows, and western silvery minnows found over sand and gravel bars. The few pallid sturgeon in captivity are successfully fed goldfish, crayfish, and minnows.

Pallid sturgeon are known to hybridize with the smaller shovelnose sturgeon. In the lower Mississippi River in Missouri, hybrids are more common than pallid sturgeon. Hybrids were first identified in the Mississippi River below St. Louis, Missouri, in the late 1970's. More recently, hybrids have been captured not only near St. Louis, but near the Old River Control structure in east central Louisiana in the Mississippi and Atchafalaya rivers. These hybrids may constitute a serious threat to the survival of pallid sturgeon in the southern portion of their range because of competition and the potential for genetic swamping.

Pallid sturgeon were first artificially spawned by the Missouri Department of Conservation in 1992. A number of other Federal and state resource agencies are conducting studies to improve culture of this species. These studies include techniques to improve spawning to insure survival of broodstock and production of viable eggs and fry, and studies to identify foods and feeding techniques to improve growth and survival of fingerling and adult fish. Successful completion of these and other studies will benefit management of this species.

The pallid sturgeon was listed as an endangered species on September 6, 1990, in accordance with provisions of the Endangered Species Act of 1973, as amended.

### **Shovelnose Sturgeon: *Scaphirhynchus platorhynchus* (Rafinesque)**

The shovelnose sturgeon is a freshwater species that was historically found throughout most of the Mississippi and Missouri river basins, from Montana south to Louisiana, and from Pennsylvania west to New Mexico. This sturgeon species presently has a more limited range due to human impacts. While the shovelnose has not experienced the range reduction of some of the larger Mississippi River Valley sturgeons (e.g., lake and pallid), it is no longer found in Pennsylvania, New Mexico, and large parts of Kansas, Kentucky, Tennessee, and other states where it was once abundant.

Shovelnose sturgeon, smallest of the sturgeon species in North America, can tolerate high turbidities and are usually found in the strong currents of main river channels. They are often found over sand and gravel substrates feeding on aquatic insects, mussels, worms, and crustaceans. Normally, spawning occurs from April through early July with mature shovelnose migrating upriver to spawn over rocky substrates in flowing water between 19 and 21°C. Individuals mature after 5 to 7 years of age, at approximately 500 mm and 630 mm for males and females, respectively. Their weight at this age ranges from 0.9 to 1.3 kg. The largest recorded shovelnose was approximately 900 mm and weighed 3-4 kg.

The alteration of large rivers and construction of locks and dams for navigation purposes have contributed significantly to the decline of this species by blocking access to ancestral spawning grounds and by eliminating its requisite lotic habitat. While the shovelnose sturgeon's roe is used as an acceptable caviar, overharvest has not been a major detriment to this species. This may be due to its relatively small size in comparison to the other two sturgeon species found historically throughout its range (i.e., lake and pallid). The shovelnose is locally abundant in some areas where the large river habitat it needs is still fairly intact. Modest commercial fisheries occur in a few

states where some acceptable riverine habitat still exists. For example, in Arkansas 14,500 kg were harvested annually from the White River in the 1980's, and in Iowa 7,000 kg were harvested from the Mississippi River in 1990.

Federal and state hatcheries have developed spawning techniques for this species which are similar to those used to produce paddlefish in Missouri and white sturgeon in California. Unlike the paddlefish and white sturgeon though, at present, there is little interest by private aquaculturists in working with shovelnose as a source of flesh or caviar. However, there is some interest in their potential trade as an aquarium fish.

### **Alabama Sturgeon: *Scaphirhynchus suttkusi* Williams and Clemmer**

The Alabama sturgeon is a freshwater species known only from the Mobile River system of Alabama and Mississippi. Within the Mobile River system, the species is historically reported from the Tombigbee, Black Warrior, Cahaba, Alabama, and Mobile rivers, Alabama; and the Tombigbee River, Mississippi. Prior to impoundment, this small sturgeon's range likely included the Coosa and Tallapoosa rivers, Alabama. The species was last captured in 1985 during a survey conducted to determine its status. Since that time there have been numerous anecdotal reports of captures by fishermen, but none have been caught in the limited sampling conducted by State and Federal conservation agencies. All confirmed captures and anecdotal reports of capture in the past several years have come from the Alabama River, downstream of Jones Bluff Lock and Dam, and from the lower Cahaba River. The species has not been reported from the Black Warrior River since the turn of the century and only a small number of Alabama sturgeon have been reported from the Tombigbee River. The Mobile River is likely marginal habitat due to saltwater intrusion.

The decline of this species is related to the alteration of the Mobile River system by the construction of locks and dams for navigation and hydroelectric production. The construction of dams likely blocked access to spawning grounds and eliminated lotic habitat required by the sturgeon. While this species was commercially traded in the late 1800's, there is no reason to believe it was over-harvested. There are no records of this species in commercial trade after the turn of the century.

The biology and specific habitat needs of the Alabama sturgeon are largely unknown. The life history requirements for the Alabama sturgeon are likely similar to those of the shovelnose sturgeon, its closest relative, however. They are about equal in size, the Alabama sturgeon attains a length of 720 mm, and based upon gravid females captured during sampling, probably reproduce under similar conditions.

Based on limited capture information, the Alabama sturgeon seems to prefer unmodified main channels of large coastal plain rivers as non-spawning habitat. Most specimens have been taken in moderate to swift currents at depths of 6 to 14 m, over sand and gravel or mud bottom. Alabama sturgeon migrate upstream to spawn. Spawning habitats may be tributaries with hard substrates, main channel areas, or in the directed currents of water diversion structures (i.e., wing walls, training dikes, and closing dams) in major rivers. Spawning apparently occurs from April to July. The spawning period probably depends upon water temperature and current. Based on limited stomach analysis, Alabama sturgeon appear to be opportunistic bottom feeders, with aquatic insect larvae being a major dietary component. Fish eggs, snails, mussels, and fish are also taken.

The U.S. Fish and Wildlife Service is reviewing a rule to propose the Alabama sturgeon for endangered status and to designate critical habitat. Should this species be listed as endangered, it is likely that Federal and State hatcheries will culture and stock it to enhance the small wild population. Spawning techniques developed for other sturgeon, especially the shovelnose sturgeon, should be effective for the Alabama sturgeon. It is doubtful there will be any interest in private aquaculture of this species.

### **Paddlefish: *Polyodon spathula* (Walbaum)**

Paddlefish belong to the same order (Acipenseriformes) as sturgeon but are in the family Polyodontidae. The paddlefish, an open-water species, was once common throughout much of the Mississippi River Basin, adjacent Gulf drainages, and some areas in the Great Lakes. Under the relatively natural, unaltered conditions that existed prior to the early 1900's, paddlefish inhabited large, free-flowing rivers with braided channels, extensive backwaters, and oxbow lakes. These areas provided ideal habitat for spawning and provided areas rich in zooplankton, their primary diet. However, paddlefish are now found in only a portion of their former range. Since about 1900 significant declines in major paddlefish stocks have occurred in the Mississippi, Missouri, Ohio and Red river drainages, and adjacent Gulf drainages. A relict population has also been lost from the Great Lakes.

One of the primary reasons for the decline in paddlefish populations since the turn of the century is the loss of spawning and rearing habitat due to environmental alteration. Dam construction has eliminated spawning sites, interrupted natural spawning migrations, altered water flow, and eliminated backwaters that were important as nursery and feeding areas. Industrial contaminants, illegal fishing, and over-exploitation

by commercial and recreational anglers have also contributed to the decline.

Unfortunately, population problems are not always immediately recognized because paddlefish are long-lived and highly mobile, and their presence is sometimes construed as an indication that the species has not been adversely affected. For the future survival of this species, however, effective management will require a better awareness of how environmental factors affect paddlefish and a better understanding of the life history and basic biological requirements of the species.

In the Midwest, females usually do not reach sexual maturity until at least 10 years of age; males reach sexual maturity at about 8 years of age. When they first reach maturity, females generally weigh at least 13-14 kg and males weigh 7-9 kg. Paddlefish in some southern waters reach sexual maturity at an earlier age and at smaller sizes. Some southern paddlefish females are sexually mature at about 7 or 8 years of age (8-9 kg) and some southern paddlefish males reach maturity at about 5-6 years of age (5-7 kg). Paddlefish generally grow faster in reservoirs than in rivers, presumably because of increased abundance and availability of food. They can easily gain 2.3-2.7 kg per year and can attain weights exceeding 45 kg.

Paddlefish require precise timing of events for successful reproduction. They spawn over gravel substrate in the flowing waters of large rivers. The three most important factors controlling spawning are photoperiod, water temperature, and water flow. Photoperiod and water temperature (10-16°C) control the timing of spawning, but an increase in water flow is the triggering stimulus.

Techniques for the spawning and culture of paddlefish were developed in the late 1960's. These methods have been modified and improved during the last several years. Paddlefish fingerlings are now reared both intensively (raceways and circular tanks) and extensively (ponds), and techniques have been developed to train paddlefish to accept commercial diets. These advances in culture technology, and the high demand for paddlefish as a source of caviar and smoked flesh, has increased interest in the private aquaculture community for this species.

The commercial catch of paddlefish has fluctuated since the late 1800's, varying with demand for roe and smoked flesh, which was often substituted for sturgeon caviar and smoked sturgeon. This varying demand has caused many paddlefish fisheries to experience serious "boom and bust" cycles. In these cycles, overexploitation usually resulted and then, due to the unprofitability of fishing for these species, the stocks were left to recover -- a process that sometimes took decades. Unfortunately, many paddlefish stocks are currently being commercially harvested using similar "boom and bust" logic.

Because of the overall reduction in demand for paddlefish flesh and caviar over the last several decades, commercial catches are but a fraction of what they were in the early 1900's; however, since the 1980's, demand for caviar has increased and pressures are once again being placed on paddlefish. In recent years, depending upon supply and demand, the price of unprocessed paddlefish eggs has fluctuated from \$30 to \$90 per pound, with a potential value of \$250 to \$700 per fish. Because of this high value, illegal fishing has seriously damaged paddlefish fisheries in several reservoirs in the Midwest and southeastern United States.

In addition to their commercial value, paddlefish are also an important sport fish in several Midwestern and Southeastern states. In these states paddlefish fisheries are managed by seasons and bag limits to ensure sustained harvests.

## **APPENDIX II**

### **LIST OF U.S. FISH AND WILDLIFE SERVICE ENTITIES INVOLVED IN THE MANAGEMENT AND CONSERVATION OF PADDLEFISH AND STURGEON**

#### **Shortnose sturgeon:**

- Bears Bluff NFH, Wadmalaw Island, SC
- Bo Ginn NFH, Millen, GA
- Conte Anadromous Fish Research Laboratory, Turners Falls, MA
- Edenton NFH, Edenton, NC
- National Fisheries Research Center--Gainesville,  
Gainesville, FL
- Orangeburg NFH, Orangeburg, SC
- Wadmalaw Island FAO, Wadmalaw Island, SC

#### **Lake sturgeon:**

- Alpena Fishery Resources Office, Alpena, MI
- Ashland Fishery Resources Office, Ashland, WI
- Cartersville Fishery Resources Office, Cartersville, IL
- Columbia Fishery Resources Office, Columbia, MO
- Fish and Wildlife Enhancement Office, Columbia, MO
- Fish and Wildlife Enhancement Office, East Lansing, MI
- Genoa NFH, Genoa, WI
- Green Bay Fishery Resources Office, Green Bay, WI
- Large Rivers Fishery Coordination Office, Columbia, MO
- Lower Great Lakes Fishery Resources Office, Buffalo, NY
- National Fishery Research and Development Laboratory--  
Wellsboro, Wellsboro, PA
- Winona Fishery Resource Office, Winona, MN

#### **Green sturgeon:**

- Abernathy Salmon Culture Technology Center, Longview, WA
- Coastal California Fishery Resource Office, Arcata, CA
- Lower Columbia River Fishery Resource Office, Vancouver, WA

#### **Atlantic Sturgeon:**

- Bears Bluff NFH, Wadmalaw, Island, SC
- Conte Anadromous Fish Research Laboratory, Turners Falls, MA
- National Fishery Research and Development Laboratory--  
Wellsboro, Wellsboro, PA
- Northeast Fishery Center, Lamar, PA
- Northeast Fish Health Unit, Lamar, PA
- Susquehanna River Coordinator, Harrisburg, PA
- Tunison Laboratory of Fish Nutrition, Cortland, NY
- Warm Springs NFH, Warm Springs, GA
- Welaka NFH, Welaka, FL

Atlantic Sturgeon:

- Bears Bluff NFH, Wadmalaw, Island, SC
- Conte Anadromous Fish Research Laboratory, Turners Falls, MA
- National Fishery Research and Development Laboratory--  
Wellsboro, Wellsboro, PA
- Northeast Fishery Center, Lamar, PA
- Northeast Fish Health Unit, Lamar, PA
- Susquehanna River Coordinator, Harrisburg, PA
- Tunison Laboratory of Fish Nutrition, Cortland, NY

White Sturgeon:

- Abernathy Salmon Culture Technology Center, Longview, WA
- Coastal California Fishery Resource Office, Arcata, CA
- Columbia River Field Station, Cook, WA
- Fish and Wildlife Enhancement Office, Boise, ID
- Idaho Cooperative Fishery Research Unit, Moscow, ID
- Idaho Fishery Resource Office, Ahsahka, ID
- Lower Columbia River Fishery Resource Office, Vancouver, WA
- National Fisheries Research Center--Seattle, Seattle, WA
- Northern Central Valley Fishery Resource Office,  
Red Bluff, CA
- Western Washington Fishery Resource Office, Olympia, WA

Pallid Sturgeon:

- Bozeman FTC, Bozeman, MT
- Carterville Fishery Resource Office, Carterville, IL
- Columbia Fishery Resources Office, Columbia, MO
- Fish and wildlife Enhancement Office, Bismarck, ND
- Fish and Wildlife Enhancement Office, Columbia, MO
- Fish and Wildlife Enhancement Office, Jackson, MS
- Fish and wildlife Enhancement Office, Lafayette, LA
- Fish and wildlife Enhancement Office, Pierre, SD
- Fish and wildlife Enhancement Office, Vicksburg, MS
- Fort Morgan Fish Disease Control Center, Fort Morgan, CO
- Garrison Darn NFH, Riverdale, ND
- Gavins Point NFH, Yankton, SD
- Gulf Coast FCO, Ocean Springs, MS
- Large Rivers Fishery Coordination Office, Columbia, MO
- Missouri River Coordinator, Pierre, SD
- Missouri River Fish and wildlife Management Assistance  
Office, Bismarck, ND
- Montana Cooperative Fishery Research Unit, Bozeman, MT
- Natchitoches FAO, Natchitoches, LA
- Natchitoches NFH, Natchitoches, LA
- Neosho NFH, Neosho, MO
- South Dakota Cooperative Fishery Research Unit, Brookings, SD
- Valley City NFH, Valley City, ND

Shovelnose sturgeon:

- Bozeman FTC, Bozeman, MT
- Carterville Fishery Resource Office, Carterville, IL
- Columbia Fishery Resources Office, Columbia, MO
- Fish and Wildlife Enhancement Office, Columbia, MO
- Fort Morgan Fish Disease Control Center, Fort Morgan, CO

- Garrison Dam NFH, Riverdale, ND
- Gavins Point NFH, Yankton, SD
- Large Rivers Fishery Coordination Office, Columbia, MO
- Missouri River Coordinator, Pierre, SD
- Missouri River Fish and Wildlife Management Assistance Office, Bismarck, ND
- Montana Cooperative Fishery Research Unit, Bozeman, MT
- Natchitoches NFH, Natchitoches, LA -Valley City NFH, Valley City, ND
- Winona Fishery Resources Office, Winona, MN

#### Alabama sturgeon:

- Fish and wildlife Enhancement Office, Daphne, AL
- Fish and wildlife Enhancement Office, Jackson, MS
- Fish and wildlife Enhancement Office, Jacksonville, FL
- Fish and Wildlife Enhancement Office, Panama City, FL
- Gulf Coast FCO, Ocean Springs, MS
- National Fisheries Research Center--Gainesville, Gainesville, FL.
- Panama City FAO, Panama City, FL

#### Paddlefish:

- Bowden NFH, Elkins, WV
- Bozeman FTC, Bozeman, MT
- Carbon Hill NFH, Carbon Hill, AL
- Carterville Fishery Resources Office, Carterville, IL
- Columbia Fishery Resources Office, Columbia, MO
- Fish and Wildlife Enhancement Office, Columbia, MO
- Fort Morgan Fish Disease Control Center, Fort Morgan, CO
- Garrison Dam NFH, Riverdale, ND
- Gavins Point NFH, Yankton, SD
- Genoa NFH, Genoa, WI
- Gulf Coast FCO, Ocean Springs, MS
- Inks Dam NFH, Burnet, TX
- Large Rivers Fishery Coordination Office, Columbia, MO
- Mammoth Spring NFH, Mammoth Spring, AR
- Meridian NFH, Meridian, MS
- Missouri River Coordinator, Pierre, SD
- Missouri River Fish and Wildlife Management Assistance Office, Bismarck, ND
- Montana Cooperative Fishery Research Unit, Bozeman, MT
- Natchitoches FAO, Natchitoches, LA
- Natchitoches NFH, Natchitoches, LA -Neosho NFH, Neosho, MO
- Private John Allen NFH, Tupelo, MS
- San Marcos NFH&TC, San Marcos, TX
- Tishomingo NFH, Tishomingo, OK
- Uvalde NFH, Uvalde, TX
- Valley City NFH, Valley City, ND
- Warm Springs NFH, Warm Springs, GA
- Winona Fishery Resource Office, Winona, MN

### **APPENDIX III**

#### **LIST OF STATE FISHERY RESOURCE AGENCIES INVOLVED IN THE MANAGEMENT AND CONSERVATION OF PADDLEFISH AND STURGEON**

##### **Shortnose sturgeon:**

- Georgia Department of Natural Resources
- Maine Department of Marine Resources
- Massachusetts Division of Marine Fisheries
- New York Department of Environmental Conservation
- South Carolina wildlife and Marine Resources Department

##### **Lake Sturgeon:**

- Michigan Department of Natural Resources
- Minnesota Department of Natural Resources
- Missouri Department of Conservation
- New York Department of Environmental Conservation
- Vermont Department of Fish and wildlife
- Wisconsin Department of Natural Resources

##### **Green Sturgeon:**

- California Department of Fish and Game
- Oregon Department of Fish and Wildlife
- Washington Department of Fisheries

##### **Gulf Sturgeon:**

- Alabama Department of Conservation and Natural Resources
- Florida Department of Natural Resources
- Louisiana Department of Wildlife and Fisheries
- Mississippi Department of Wildlife, Fisheries, and Parks

##### **Atlantic Sturgeon:**

- Connecticut Department of Environmental Protection
- Delaware Department of Natural Resources and Environmental Control
- Florida Department of Natural Resources
- Georgia Department of Natural Resources
- Maine Department of Inland Fisheries and Wildlife
- Maryland Department of Natural Resources
- Massachusetts Department of Fisheries, wildlife and Environmental Law Enforcement
- New Hampshire Department of Fish and Game
- New Jersey Department of Environmental Protection
- New York Department of Environmental Conservation
- North Carolina Department of Environment, Health, and Natural Resources
- Pennsylvania Fish Commission

- Rhode Island Department of Environmental Management
- South Carolina wildlife and Marine Resources Department
- Virginia Department of Game and Inland Fisheries

White Sturgeon:

- California Department of Fish and Game
- Idaho Department of Fish and Game
- Montana Department of Fish, Wildlife, and Parks
- Oregon Department of Fish and wildlife
- Washington Department of Fisheries

Pallid Sturgeon:

- Arkansas Game and Fish Commission
- Iowa Department of Natural Resources
- Kansas Department of wildlife and Parks
- Louisiana Department of wildlife and Fisheries
- Mississippi Department of Wildlife, Fisheries, and Parks
- Missouri Department of Conservation
- Montana Department of Fish, Wildlife, and Parks
- Nebraska Game and Parks Commission
- North Dakota State Game and Fish Department
- South Dakota Game, Fish, and Parks Department

Shovelnose Sturgeon:

- Arkansas Game and Fish Commission
- Illinois Department of Conservation
- Iowa Department of Natural Resources
- Louisiana Department of Wildlife and Fisheries
- Minnesota Department of Natural Resources
- Missouri Department of Conservation
- Montana Department of Fish, Wildlife, and Parks
- Nebraska Game and Parks Commission
- North Dakota State Game and Fish Department
- South Dakota Game, Fish, and Parks Department
- Wisconsin Department of Natural Resources

Alabama Sturgeon:

- Alabama Department of Conservation and Natural Resources

Paddlefish:

- Alabama Department of Conservation and Natural Resources
- Arkansas Game and Fish Commission
- Illinois Department of Conservation
- Indiana Department of Natural Resources
- Iowa Department of Natural Resources
- Kansas Department of wildlife and Parks
- Kentucky Department of Fish and wildlife Resources
- Louisiana Department of wildlife and Fisheries
- Minnesota Department of Natural Resources
- Mississippi Department of Wildlife, Fisheries, and Parks
- Missouri Department of Conservation
- Montana Department of Fish, Wildlife, and Parks
- Nebraska Game and Parks Commission
- North Dakota Game and Fish Department

- Ohio Department of Natural Resources
- Oklahoma Department of Wildlife Conservation
- Pennsylvania Fish Commission
- South Dakota Game, Fish, and Parks Department
- Tennessee wildlife Resources Agency
- Texas Parks and Wildlife Department
- Virginia Department of Game and Inland Fisheries
- West Virginia Division of Natural Resources
- Wisconsin Department of Natural Resources

## **APPENDIX IV**

### **LIST OF OTHER FEDERAL, STATE, AND TRIBAL ENTITIES . INVOLVED IN THE MANAGEMENT AND CONSERVATION OF PADDLEFISH AND STURGEON**

#### **Shortnose sturgeon:**

- National Marine Fisheries Service
- University of Massachusetts, MA

#### **Lake Sturgeon:**

- Bad River Band of Lake Superior Chippewa, WI
- Michigan Technological University, MI
- Mississippi Interstate Cooperative Resource Agreement
- Missouri River Natural Resources Committee
- St. Regis Mohawk Tribe, NY
- Tennessee Valley Authority
- University of Wisconsin--Milwaukee, WI
- Upper Mississippi River Conservation Committee

#### **Green Sturgeon:**

- Columbia River Intertribal Fish Commission
- Hoopa Valley Business Council, Department of Fisheries, CA
- Humboldt state University, CA
- Karuk Tribe, CA
- Pacific states Marine Fisheries Commission
- University of California--Davis, CA
- Yurok Tribe, CA

#### **Gulf Sturgeon:**

- Gulf states Marine Fisheries Commission
- National Marine Fisheries Service
- University of Florida--Gainesville, FL
- U.S. Army Corps of Engineers

#### **Atlantic Sturgeon:**

- Atlantic States Marine Fisheries Commission
- National Marine Fisheries Service
- University of Maryland, MD
- University of Massachusetts, MA
- Virginia Commonwealth University, VA

#### **White sturgeon:**

- Bonneville Power Administration
- Bureau of Reclamation
- College of Southern Idaho, ID
- Columbia River Intertribal Fish Commission
- Eastern Washington University, WA

- Humboldt state University, CA
- Hoopa Valley Business Council, Department of Fisheries, CA
- Karuk Tribe, Orleans, CA
- Kootenai Tribe, ID
- National Marine Fisheries Service
- Northwest Indian Fisheries Commission
- Pacific states Marine Fisheries Commission
- University of California--Davis, CA
- University of Idaho, ID
- Upper Columbia United Tribes, WA
- U.S. Army Corps of Engineers
- Yurok Tribe, CA

#### Pallid Sturgeon:

- Bureau of Reclamation
- Environmental Protection Agency
- Louisiana State University, LA
- Mississippi Interstate Cooperative Resource Agreement
- Missouri River Natural Resources Committee
- University of Missouri, MO
- University of North Dakota, ND
- Upper Mississippi River Conservation Committee
- U.S. Army Corps of Engineers
- Western Area Power Administration

#### Shovelnose Sturgeon:

- Bureau of Reclamation
- Environmental Protection Agency
- Louisiana state University, LA
- Mississippi Interstate Cooperative Resource Agreement
- Missouri River Natural Resources Committee
- South Dakota State, SD
- University of North Dakota, ND
- Upper Mississippi River Conservation Committee
- U.S. Army Corps of Engineers

#### Alabama Sturgeon

- Geological Survey of Alabama, AL
- Marion State Fish Hatchery, Marion, AL
- U.S. Army Corps of Engineers

#### Paddlefish:

- Iowa State University, IA
- Kentucky State University, KY
- Louisiana State University, LA
- Mississippi Interstate Cooperative Resource Agreement
- Missouri River Natural Resources Committee
- Ohio State University, OH
- Tennessee Tech University, TN
- Tennessee Valley Authority
- University of Idaho, ID
- University of North Dakota, ND
- University of Oklahoma--Norman, OK
- University of South Dakota, SD

- Upper Mississippi River Conservation Committee
- U.S. Army Corps of Engineers

## **APPENDIX V**

### **LIST OF ESTABLISHED PRIVATE ENTITIES INVOLVED IN THE CULTURE, MANAGEMENT, OR CONSERVATION OF PADDLEFISH AND STURGEON (e.g., Producers, Sellers)**

#### Shortnose sturgeon:

- Hudson River Foundation, New York City, NY

#### Lake sturgeon:

- Sturgeon for Tomorrow, Malone, WI

#### Green sturgeon:

- None exist

#### Gulf sturgeon:

- Caribbean Conservation Corporation, Gainesville, FL
- Gulf Coast Research Laboratory, Ocean Springs, MS

#### Atlantic Sturgeon:

- Hudson River Foundation, New York City, NY

#### White Sturgeon:

- FishPro Farms, Port Orchard, WA
- Pelfrey's Sturgeon Hatchery, Troutdale, OR
- Sea Farm Washington, Inc., Herald, CA
- Sierra Aquafarms, Inc., Elverta, CA
- The Fishery, Inc., Galt, CA

#### Pallid Sturgeon:

- Louisiana Hydroelectric, Vidalia, LA

#### Shovelnose Sturgeon:

- David Mueller, Mahtomedi, MN

#### Alabama Sturgeon:

- None exist

#### Paddlefish:

- Down on the Farm, Inc., Prestonsburg, KY
- Osage Catfisheries, Lake Ozark, MO
- David Mueller, Mahtomedi, MN
- Pineland Plantation, Newton, GA

## APPENDIX VI

### **LIST OF EXISTING PADDLEFISH AND STURGEON FEDERAL AND STATE MANAGEMENT PLANS**

Shortnose sturgeon:

- Shortnose Sturgeon Recovery Team Recommendations(draft)

Lake sturgeon:

- New York state has a restoration plan.
- A Plan For The Recovery Of Lake Sturgeon In Missouri

Green sturgeon:

- None exist

Gulf sturgeon:

- A management/recovery plan is being developed by the Gulf sturgeon recovery team and the Gulf states Marine Fisheries Commission

Atlantic sturgeon:

- Atlantic states Marine Fisheries Commission, Fisheries Management Report No. 17, November, 1990

White sturgeon:

- Pacific States Marine Fisheries Commission, Portland, OR, White sturgeon Management Framework Plan (August, 1992)

Pallid sturgeon:

- A recovery plan is currently being developed for pallid sturgeon.

Shovelnose sturgeon:

- None exist

Alabama sturgeon:

- None exist

Paddlefish:

- The Pennsylvania Fish Commission has a ten-year plan for stocking paddlefish in their waters of the upper Ohio and Allegheny Rivers.
- Texas Parks and Wildlife Department has a Paddlefish Recovery Program which calls for ten years of stocking in five river systems: Trinity, Neches, Sabine, Big Cypress Bayou, and Sulphur.
- A Management Plan For Paddlefish In Missouri

## **APPENDIX VII**

### **COMMITTEE MEMBERS**

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Theodore I.J. Smith  
South Carolina Wildlife  
& Marine Resources Department  
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Charleston, SC 29422

## **APPENDIX VIII**

### **GLOSSARY**

|        |                                                          |
|--------|----------------------------------------------------------|
| ASMFC  | -- Atlantic States Marine Fisheries Commission           |
| FAO    | -- Fisheries Assistance Office                           |
| FCO    | -- Fisheries Coordinator Office                          |
| FRO    | -- Fisheries Resources Office                            |
| FTC    | -- Fish Technology Center                                |
| GSMFC  | -- Gulf States Marine Fisheries Commission               |
| MICRA  | -- Mississippi Interstate Cooperative Resource Agreement |
| MRNRC  | -- Missouri River Natural Resources Committee            |
| NFH    | -- National Fish Hatchery                                |
| NFH&TC | -- National Fish Hatchery and Technology Center          |
| NMFS   | -- National Marine Fisheries Service                     |
| NOAA   | -- National Oceanic and Atmospheric Administration       |
| OFA    | -- Office of Fisheries Assistance                        |
| OFR    | -- Office of Fisheries Resources                         |
| PSMFC  | -- Pacific States Marine Fisheries Commission            |
| TC     | -- Technology Center                                     |
| UMRCC  | -- Upper Mississippi River Conservation Committee        |
| USFWS  | -- United States Fish and wildlife Service               |