Fisheries Management Report No. 17

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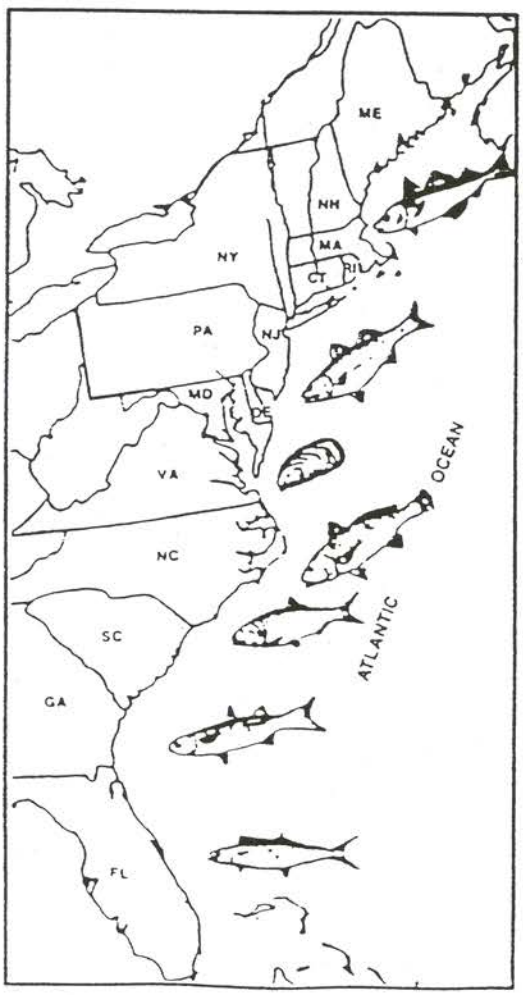
ATLANTIC STATES MARINE FISHERIES COMMISSION



FISHERY MANAGEMENT PLAN FOR ATLANTIC STURGEON

November 1990

FISHERY MANAGEMENT PLAN

FOR

ATLANTIC STURGEON (*Acipenser oxyrhynchus oxyrhynchus*)

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Washington, D.C. 20240

-1990-

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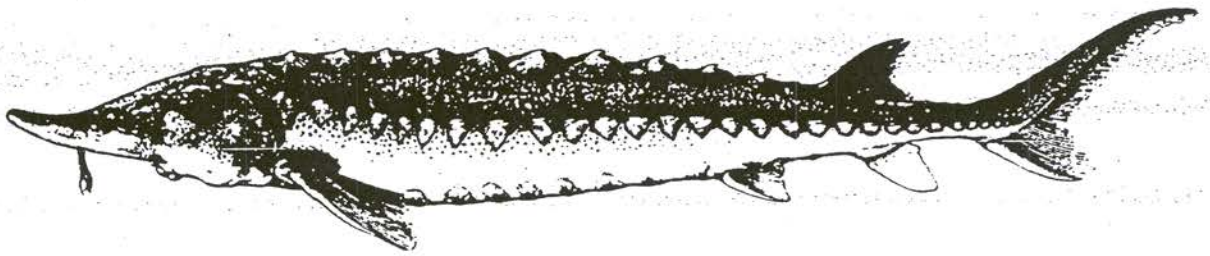

Atlantic sturgeon, *Acipenser oxyrhynchus oxyrhynchus*, (Vladykov and Greeley, 1963).

1.0 EXECUTIVE SUMMARY

Atlantic sturgeon once could be found in great abundance along the United States East Coast. However, the species and its fisheries suffered severe declines during the late 1800's and early 1900's. Remnant populations still persist and some small scale fisheries continue for the species to this day. The Atlantic States Marine Fisheries Commission (ASMFC) began development of this fishery management plan in 1988 in order to effect better coastwide management of Atlantic sturgeon throughout their range. The FMP was officially adopted by ASMFC in November, 1990.

Goal of Fishery Management Plan (FMP)

The goal of this FMP is to provide the framework to allow the restoration of the Atlantic sturgeon resource to fishable abundance throughout its range. For purposes of this FMP, fishable abundance is defined as 700,000 pounds per year, which is 10 percent of the 1890 landings of 7 million pounds.

The FMP objectives and management measures focus on alleviating the following problems;

PROBLEMS:

1. Regulations in some States allow harvest before females have the opportunity to spawn once. A size of seven feet (7.0) total length (TL) approximates the length at first maturity for females throughout the range of the species.

2. There are significant gaps in our knowledge of this species. For example, information on specific locations of spawning sites is needed to better protect these habitats, little is known about early life history, and only sketchy information exists on migratory patterns.

3. Atlantic sturgeon culture is hampered by several factors: the general scarcity of broodstock sources, difficultly of handling and holding large fish, and difficulty of simultaneously obtaining ripe females and males, and the lack of suitable nursery systems.

MANAGEMENT OBJECTIVES:

1. Protect Atlantic sturgeon from further depletion.

2. Improve knowledge of the Atlantic sturgeon stock.

3. Enhance and restore the stock of Atlantic sturgeon.

4. Coordinate Atlantic sturgeon research and management activities throughout the Atlantic coast range.

MANAGEMENT RECOMMENDATIONS:

The following management recommendations, in priority order, are identified as necessary to meet the goals and objectives of this FMP.

1. Each State should control harvest to increase spawning biomass by adopting either:

   a. A minimum TL of at least seven (7.0) feet (75 inches FL) and institute a monitoring program, with at least mandatory reporting of commercial landings, or

   b. A moratorium on all harvest, or

   c. If a State deviates from the above, the State should submit alternative measures to the ASMFC Atlantic Sturgeon Plan Review Team for determination of conservation equivalency.

2. Each State should identify, characterize, and protect critical spawning and nursery areas.

3. Each State should establish tagging projects to delineate migratory patterns, age and growth, population estimates, and mortality rates.

4. Each State should identify critical habitat characteristics of staging and oceanic areas.

5. The ASMFC should encourage and coordinate a coastwide depository of data and information required to effectively monitor and assess management efforts.

6. The ASMFC should encourage an expanded aquaculture effort to develop techniques to rear Atlantic sturgeon and evaluate hatchery fish for stock restoration.

7. The ASMFC should encourage shortnose sturgeon researchers to also incorporate Atlantic sturgeon into their projects.

8. The ASMFC should encourage determination of environmental tolerance levels (D.O., pH, temperature, river flow, salinity, etc.) for all life stages.

9. The ASMFC should encourage the determination of effects of contaminants on all life stages, especially eggs, larvae, and juveniles.

10. The ASMFC should encourage the evaluation of existing fisheries survey data to aid in determining at-sea migratory behavior and stock composition.

11. The ASMFC should encourage aquaculture research to identify and control early life stage diseases, synchronize spawning times of males and females, and reduce handling stress problems.

12. The ASMFC should encourage the appropriate Federal fisheries management agencies to manage the Atlantic sturgeon fishery in the Exclusive Economic Zone (EEZ).

13. The ASMFC should establish an aquaculture and stocking committee to provide guidelines for aquaculture and restoration stocking of sturgeon.

2.0 CONTENTS

3.0 INTRODUCTION

3.1 Development of the FMP

This Atlantic sturgeon, *Acipenser oxyrhynchus oxyrhynchus*, FMP was prepared through the auspices of the Atlantic States Marine Fisheries Commission (ASMFC). The U.S. Fish and Wildlife Service (Service) provided the plan writer, Stephen H. Taub, Senior Fishery Biologist, for this project. The project began in 1988, and consisted of reviewing the literature, and communicating with experts. There are four recent review papers of Atlantic sturgeon. They are: Murawski and Pacheco (1977), Hoff (1980), Van Den Avyle (1984), and Gilbert (1989). When there was an absence of specific data for Atlantic sturgeon, cited information on other sturgeon species, when available, was used.

The Atlantic Sturgeon Board of the ASMFC determined that the goal of the FMP is to restore and enhance the stock of Atlantic sturgeon. The four major objectives of the FMP are to: (1) protect the stock from further depletion; (2) improve knowledge of Atlantic sturgeon; (3) restore the stock of Atlantic sturgeon based on life history determinations; and (4) coordinate Atlantic sturgeon research and management activities throughout the Atlantic coast range of the species.

This FMP follows the format of other ASMFC fishery management plans. Accordingly, there is repetition to accommodate those who wish to read some sections, but not the entire FMP.

3.2 Problems Addressed by the FMP

Fishery management decisions need to be based, in part, on accurate knowledge of the biology, ecology, and population dynamics of the species. The major impediment to effective management of Atlantic sturgeon is the lack of stock assessment data. Basic data requirements include information on recruitment, age, size, and sex composition. Accurate catch and effort data are needed from the commercial fisheries. At present, management regulations are inconsistent among the States.

The incidental catch and discard mortality of juvenile, sub-adult, and adult Atlantic sturgeon[1] in non-directed fisheries, such as the mid-Atlantic trawl fisheries, has been cited as having potentially significant negative impacts on the Atlantic sturgeon stock.

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1 Juvenile - All post larval sturgeon that remain year-round in riverine and estuarine environments.

Sub-adult - Immature sturgeon seasonally occupying riverine and meritic environments.

Adult-Sexually mature sturgeon, wherever they occur.

The population size and age structure of Atlantic sturgeon is unknown. Since considerable migratory behavior is exhibited by the species, and there is not contrary information, this FMP treats Atlantic sturgeon as a single stock.

4.0 DESCRIPTION OF THE STOCK

4.1 Species Distribution

Atlantic sturgeon are anadromous, occurring in the ocean, estuaries, and large rivers of the Atlantic coast. There are two subspecies of Atlantic sturgeon. The subspecies *Acipenser oxyrhynchus oxyrhynchus*, is distributed from Hamilton Inlet, Labrador to the St. Lucies River, Florida, while the subspecies *A. o. desotoi* occurs throughout the Gulf of Mexico, with the exception of Texas, and is often referred to as the Gulf sturgeon. These subspecies are allopatric having been separated by the emergence of the Florida peninsula. The terms "this species", and "Atlantic sturgeon", in this FMP, refer only to the Atlantic coast subspecies *A. o. oxyrhynchus*.

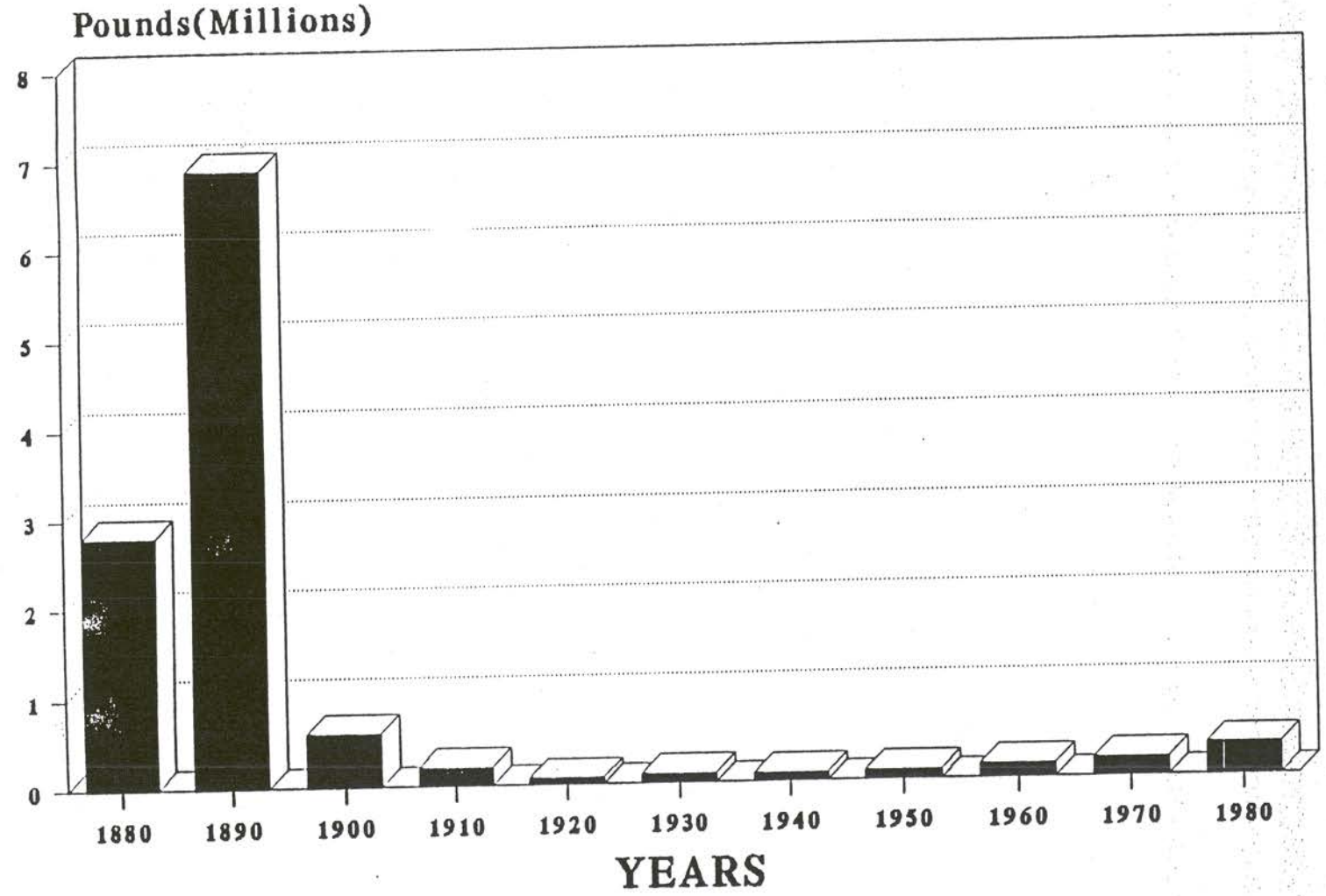
4.2 Abundance

The only long term data base available for determining coast wide abundance trends is commercial landings. Data used in landing tables are from State reports to the National Marine Fisheries Service (NMFS). However, commercial landings data may not accurately reflect abundance because of inconsistencies in reporting mixed species in a single category (the shortnose sturgeon, *Acipenser breverostrum*, was not a Federal listed endangered species until 1967), and lack of fishing effort data. The area of greatest historical abundance is the Mid-Atlantic Bight. Recent data indicates that present population concentrations occur in the Hudson River (R. Brandt, New York Department of Environmental Conservation, personal communication) and along the south Atlantic coast (Gilbert, 1989). There are limited fisheries independent data on abundance of Atlantic sturgeon. North Carolina's Division of Marine Fisheries has considerable tagging data for Atlantic sturgeon which has yet to be analyzed (M. Street, North Carolina Division of Marine Fisheries, personal communication).

Commercial records of landings from the late 1800's to the present indicate a severe decline in landings from a high of almost 7,000,000 lb in 1890 to a low of 22,000 lb in 1920. Since then, the total annual United States commercial landings have not exceeded 300,000 lb (Figure 1).

At present, small numbers remain throughout much of the species range. In the past ten years, some States have adopted stricter regulations to reduce harvest or have placed a total moratorium on the harvest of Atlantic sturgeon within their jurisdictions. Six jurisdictions (Pennsylvania, District of Columbia, Potomac River Fisheries Commission, Virginia, South Carolina, and Florida) have banned all sturgeon fishing. Hoff (1980) recommended that States ban sturgeon fishing except for a managed fishery for two ASMFC States; New York and South Carolina. In 1985, South Carolina closed their fishery because of continued

Figure 1. Atlantic sturgeon commercial landings, 1880 to 1980.



sharp declines of Atlantic sturgeon in their waters. Table 1. shows the 1990 status of Atlantic sturgeon fisheries by jurisdiction.

Table 1. Status of Atlantic sturgeon Commercial Fisheries in 1990.

Directed Fisheries*	Incidental Fisheries	Closed Fisheries
New York	Maine	Pennsylvania
New Jersey	New Hampshire	District of Columbia
Delaware	Massachusetts	Potomac River Fisheries Comm.
North Carolina	Rhode Island	Virginia
Georgia	Connecticut	South Carolina
	Maryland	Florida

* All States having directed fisheries also report incidental landings of Atlantic sturgeon.

4.3 Ecological Relationships

Food - Sturgeon are omnivorous, opportunistic feeders ingesting a wide variety of benthic invertebrates and bottom dwelling small fishes. The food of wild young-of-the-year sturgeon has not been described.

Age and Growth - Various body parts have been used to age sturgeon. Although no techniques have been validated, fin ray analyses appears to be the most commonly used method. Huff (1975) observed that there is a three-year disparity in ages in Gulf sturgeon obtained using fin rays as compared to operculi. Back calculations are very difficult to perform for sturgeon. Fastest growth occurs in Florida, and the slowest in Canada.

Females usually exceed males in length and weight at a given age. The largest documented fish was a 14' female, 60 years old, weighing 811 lb, captured in 1924 from the St. John's River, New Brunswick (Vladykov and Greeley, 1963).

Reproduction - Age at sexual maturity varies by latitude with a range of 12-27 years for females throughout their range. In the St. Lawrence River, females attain maturity at about age 27 and 7.6' TL (Scott and Scott, 1988). Female sturgeon in Georgia first attain maturity at 6-7' TL (Torrey-Ansley, 1989). In South Carolina, first maturity of females occurred at a mean TL of 7.3' (range 6.3-8.2; n=40) (Smith et al., 1982). In Maine, female maturity first occurred at 7.5' TL; however this is based on only two fish (T. Squires, Maine Department of Marine Resources, personal communication). Males mature at a smaller length than females but exhibit the same geographic latitudinal trends as females in age at first maturity.

Atlantic sturgeon begin their upriver spawning migrations in February in the southern part of their range. Dees (1961) indicated that sturgeon spawn in various salinities, depths, and over a variety of substrates. In the lower

Merrimack River, Massachusetts, Atlantic sturgeon prefer a salinity of 10.0 ppt (M. Kieffer and B. Kynard, Massachusetts Cooperative Fish and Wildlife Research Unit, personal communication). Eggs are broadcast into flowing water and are demersal and adhesive. Reported fecundity ranged from 1.0 million eggs for a 165 lb fish to 3.8 million eggs for a 353 lb fish. Spent fish gradually return to saltwater. Females do not usually spawn every year (Vladykov and Greeley, 1963).

Competition, Predators, Diseases and Parasites

There is no significant information available on these topics.

4.4 Probable Future Condition

Without remedial management actions, restoration of the stock will not be realized. The high monetary value of mature females will result in Atlantic sturgeon being overfished. Bycatch of immature fish will continue to reduce stock numbers because these fisheries will not be influenced by low catch rates of non-target species. Incidental fisheries also reduce the potential economic yield.

Regulations should take into account: (1) the interjurisdictional/migratory nature of this species; (2) the need to protect spawners through at least their first spawning; (3) the need for preservation and improvement of critical habitats; (4) problems associated with blocked access to spawning areas; and (5) the importance of aquaculture research to ensure the perpetuity of this species.

There is no single, simple solution, nor are any short-term solutions likely. Given the delayed maturity, long inter-spawning periodicity, low stock numbers, and vulnerability to overexploitation, it is anticipated that a minimum of three generations (45 years) for stock recovery will be required.

5.0 DESCRIPTION OF HABITAT

Atlantic sturgeon, being migratory, utilize a diversity of fresh and salt water environments. In 1985, a team of sturgeon experts applied the Delphi method (expert opinion) to develop habitat suitability index (HSI) curves for Atlantic sturgeon (Crance, 1987). The information developed is particularly important because it is the only current information on Atlantic sturgeon water quality/habitat suitability. A summary of the results are presented in Table 2.

Table 2. Habitat Suitability for Life Stages of Atlantic sturgeon.

Event/Stage	Velocity (ft/sec)	Depth (ft)	Substrate	Temp (°F)
Spawning/Incubation	1.5-2.5	20-40	Gravel/Cobble/Rubble	55-65
Larvae	0.5-1.5	10-40	Gravel	55-70
Juveniles	1.0-3.0	2-6	Silt/Sand	50-80
Adults	1.0-3.0	10-40	Silt/Sand	50-80

5.1 Condition of the Habitat

The principal habitat threats to the survival of Atlantic sturgeon are modifications or loss of habitat, poor water quality, and contaminants. The 1970 National Estuary Study found that dredging and filling were particularly destructive of fish habitat in estuarine systems. That study indicated that 73% of the nation's estuaries have been moderately to severely degraded.

Dredging causes physical alteration of habitat, increases siltation, and may reduce food availability, which would be especially deleterious at the onset of exogenous feeding. There is abundant anecdotal evidence to indicate that old river bottom areas not subjected to recent maintenance dredging are preferred habitat. It has been suggested that the well-developed benthic fauna on undisturbed sites provide better feeding conditions for sturgeon. Single large scale dredging projects have greater adverse impacts on several aspects of sturgeon life histories than several small scale dredgings (R Brandt, New York Department of Environmental Conservation, personal communication).

Most major river systems have dams that have severely restricted the amount of habitat available to Atlantic sturgeon. Dams close to river mouths are the most serious because they preclude nearly all upriver movement. Limited attempts with fish passage devices for Atlantic sturgeon have been unsuccessful.

5.2 Habitat Areas of Concern

All of the habitats (oceanic, estuarine, and riverine) used by various life stages of Atlantic sturgeon are necessary for the species survival. However, riverine habitat where spawning occurs, may be the most critical to maintenance of the species.

5.2.1 Spawning

Alterations to riverine spawning sites and nurseries and loss of access because of dams are of significant concern and have been suggested as a contributing cause of the depressed stock condition (Dees, 1961; Vladykov and Greeley, 1963; Leland, 1968; Murawski and Pacheco, 1977; Wooley, 1985).

5.2.2 Spawning Migrations

Males precede females by a week or longer in the winter-spring spawning migration. This migration begins in February in the southern part of its range, and occurs as late as July in the northern range (Gilbert, 1989).

A secondary fall spawning migration has been documented in certain southern rivers (Smith et al., 1982). In 1986, ripe male Atlantic sturgeon were collected below the first dam on the Savannah River (mile 187) in October, approximately 140 miles above the saltwater - freshwater interface (R. Gilbert, University of Georgia, personal communication).

The degree of fidelity to natal rivers is not well known. The timing of spawning migrations are well known and show a distinct pattern that seems to be chiefly temperature regulated (Smith, 1986). Other factors, such as river flows and photoperiod, may also affect the timing of spawning migrations.

Movements of mature Atlantic sturgeon in the Hudson estuary (defined as the river south of Troy New York, river mile 154) during the spawning season were slow, deliberate, and opportunistic with respect to tidal currents and generally restricted to deeper river channels (Dovel and Berggren, 1983).

Vladykov and Greeley (1963) described the 1925 Delaware River Atlantic sturgeon spawning migration as taking place through the river channel, 36-42' deep, and in strong current. They also stated that the spawning migration in the St. Lawrence River took place through deep channels.

5.2.3 Spawning Locations

The locations where Atlantic sturgeon spawn are not well documented (Smith, 1985). Since spawning is believed to be in deep channel areas of rivers, observations of spawning in the wild have not been made. Dovel (1979) described spawning sites in the Hudson River as the freshwater area immediately upstream from the salt front.

Recent work in southern latitudes, along with anecdotal evidence from commercial fishermen in Georgia, indicates that spawning in the Altamaha River may take place in deep freshwater eddies which are tidally influenced.

Atlantic sturgeon historically used an area 25 to 65 miles south of Philadelphia in brackish waters of the Delaware River for spawning (Murawski and Pacheco, 1977).

Information on spawning locations, timing, and associated environmental conditions in rivers remains obscure and needs to be better defined.

5.2.4 Spawning Area Characteristics

Historical spawning sites were primarily fast flowing deep river channels with hard bottoms where debris and/or ledges were present. Dees (1961) indicated that spawning occurred in running brackish or fresh water over bottoms containing rocks, rubble, and other hard objects. Bottom substrates in the Altamaha River, Georgia consist of mud and downed trees (E. Torrey-Ansley, Georgia Department of Natural Resources, personal communication). Vladykov and Greeley (1963) described the upper Delaware River bottom as hard clay where sturgeon gathered for spawning. They also speculated that Atlantic sturgeon spawned in pools below waterfalls of certain St. Lawrence River tributaries.

There is little quantitative information on spawning behavior of Atlantic sturgeon relative to flow conditions. However, Buckley and Kynard (1981) found that flow rates affected spawning success of shortnose sturgeon, *Acipenser brevirostrum*. They determined that environmental conditions suitable for spawning are apparently available for only a short period. Stabilized and regulated water discharges on the Volga River, Soviet Union increased spawning success of *Acipenser stellatus*, as cited in Wooley and Crateau (1985).

The habitat areas of concern involved with Atlantic sturgeon spawning encompass a great deal of the length of river systems, from the lower brackish areas to upper river reaches. Of particular concern for spawning are deep channels of upstream riverine freshwater sites.

5.2.5 Nursery Areas

Areas of particular concern for growth of juvenile Atlantic sturgeon are the lower portions of rivers and estuaries. The distribution and residence times of larval, post-larval, and young juveniles in upstream areas is unknown. Migration behavior to downstream nursery habitats is unknown. Young-of-the-year juveniles are very difficult to locate. Smith et al. (1982), however, reported that young-of-the-year have been captured in trawls in the lower Pee Dee, Waccamaw, and Edisto Rivers in South Carolina between mid-July and October. No young-of-the-year were taken in the estuarine regions of these rivers during other seasons.

Available juvenile data are based on collections of specimens by gill netting, trawling, or incidental capture in other gear. Young-of-the-year specimens are generally too small to be captured by such techniques. Areas of capture are described as broad, shallow (1 to 6' deep) reaches of rivers, in downstream tidally influenced transition zones having hard sand or shale bottoms kept clean by currents, with 0 to 5 ppt salinities.

Concentrations of juveniles in the general area of the salt wedge are well documented (Bigelow and Schroeder, 1953; Vladykov and Greeley, 1963; Smith et al., 1982; Dovel and Berggren, 1983). Aggregations of juveniles at the fresh water/salt water interface suggest that this is a nursery area in the Altamaha River, Georgia (E. Torrey-Ansley, Georgia Department of Natural Resources, personal communication). In Winyah Bay, South Carolina, in very cold winters, juveniles sometimes move to salt water adjacent to jetties (T. Smith, South Carolina Wildlife and Marine Resources Department, personal communication).

Juvenile Atlantic sturgeon larger than 1.5' TL were found primarily in the lower St. John River estuary, Canada, in salinities of 10 to 20 ppt (Dadswell, 1979). In the Delaware River, juvenile Atlantic sturgeon moved from the upper tidal portion to the Bay in early winter as water temperatures declined. Murawski and Pacheco (1977) suggested that Atlantic sturgeon juveniles remain in fresh and brackish water until they reached 2.5 to 3.0' in length. Smith (1985) hypothesized that, in general, juveniles remain within riverine estuarine systems for periods of about 1 to 6 years before migrating to the coast and onto the continental shelf where they grow to maturity.

5.2.6 Staging Areas

Aggregations of sexually ripe Atlantic sturgeon in nearshore or estuarine areas may suggest the existence of marine staging areas. Mature females may remain in the estuary for 4 to 6 weeks prior to the spawning run (Dovel and Berggren, 1983).

A fall outmigration staging area was reported for adult Gulf sturgeon (Wooley and Crateau, 1985). The area is 20 miles upstream of Apalachicola Bay which is under tidal influence at low flow. Also, staging at the mouth of the Apalachicola River was documented.

5.2.7 Oceanic

Little is known about the habitat used by sturgeon while at sea. NMFS bottom trawl surveys captured sub-adults at depths to 85'. Adults occasionally cross the continental shelf to offshore fishing grounds where their maximum depth of capture has been approximately 165' (Murawski and Pacheco, 1977). NMFS trawl surveys yielded few captures over a period of 16 years (1972-1988), but did identify two areas just off Sandy Hook Bay, New Jersey, which had concentrations of sub-adult Atlantic sturgeon in summer and winter (W. Jerome, National Marine Fisheries Service, personal communication). A 1970 benthic fish survey in Sandy Hook Bay, New Jersey showed that 90% of all sturgeon, of both species, were taken in the area most affected by strong tidal currents, tides, and proximity to the ocean (Wilk and Silverman, 1976).

Summary

Alterations to river and estuarine habitats can damage the stock by blocking staging areas and migration routes, restricting spawning habitat, and creating unsuitable conditions for egg hatching and survival. Habitat alterations may limit food availability at critical times, and reduce suitable nursery habitat areas. Changes in water flow and velocity could negatively impact sturgeon.

5.3 Habitat Protection Programs

State Programs

The coastal States have enacted a variety of coastal zone management laws to regulate shoreline development and protect the coastal zone which afford sturgeon some degree of habitat protection.

Highlights of Federal Applicable Legislations

Anadromous Fish Conservation Act of 1965, as amended (16 U.S.C. 757a-g)

This Act authorizes the Secretary's of Commerce and Interior to enter into grant agreements with the States and other non-Federal interests for conservation, development, and enhancement of the Nation's anadromous fishery resources.

Fish and Wildlife Act of 1956, as amended (16 U.S.C. 742a - 742j)

This Act established a comprehensive national fish and wildlife policy; directs the Secretary of the Interior to provide continuing research, extension and information services, and to take any necessary steps to develop, manage, protect and conserve fish and wildlife resources.

Fish and Wildlife Coordination Act of 1956, as amended (16 U.S.C. 661-667e)

This Act established a comprehensive national policy on fish and wildlife resources. The Act authorized programs and investigations that may be required for the development, advancement, management, conservation and protection of the fisheries resources of the United States.

National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321-4347)

This Act requires detailed environmental impact statements for proposals for legislation and other major Federal actions which may significantly affect the quality of the human environment. Prior to making the detailed statement, the responsible Federal official is required to consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. The Act also requires that documents must be available to the public and their comments must be considered.

The Federal Water Pollution Control Act and Amendments of 1972 as amended (33 U.S.C. 1251-1376)

This Act initiated major changes in the enforcement mechanism of the Federal water pollution control program from water quality standards to effluent limits. Among other things, it requires that permits be issued by the Environmental Protection Agency or the States for discharge of effluent into waters of the United States.

The Marine Protection, Research and Sanctuaries Act of 1972 (The Ocean Dumping Act) 33 U.S.C. 1401-1444

This Act regulates the transportation from the United States of material for dumping into the oceans, coastal and other waters, and the dumping of material from any source into waters over which the United States has jurisdiction. The Environmental Protection Agency is empowered to issue permits for transportation or dumping where it will not reasonably degrade or endanger human health, welfare or amenities, or the marine environment, ecological systems or economic potentialities. Section 106 of the Act provides for the provisions of the Fish and Wildlife Coordination Act to apply.

Coastal Zone Management Act of 1972 (16 U.S.C. 1451-1464) P.L. 92-583

This Act establishes a voluntary national program within the Department of Commerce to encourage coastal States to develop and implement coastal zone management plans. Funds were authorized for cost-sharing grants to States to develop their programs. Seven amendments were made through 1990 that strengthened the Act.

The Endangered Species Act of 1973 as amended (16 U.S.C. 1531-1543)

This Act provides for the conservation of threatened and endangered species by Federal action and by encouraging the establishment of State programs. The Act authorizes the listing and delisting of species and for the identification and protection of critical habitat. Section 7 requires Federal agencies to ensure that Federal actions do not jeopardize endangered species or their critical habitat.

Deepwater Port Act of 1974 (33 U.S.C. 1501-1524)

This Act establishes procedures for the location, construction and operation of deepwater ports off the coasts of the United States.

Magnuson Fishery Conservation and Management Act of 1976 (16 U.S.C. 1801-1882)

This Act establishes a fishery conservation and management regime to be implemented by the Secretary of Commerce. Establishes a fishery conservation zone extending from the limits of the territorial sea to 200 nautical miles from the baseline from which the territorial sea is measured. The Act defines fishery resources to include ". .any habitat of fish", and enjoins the Secretary to carry out a research program which must include "...the impact of pollution on fish, the impact of wetland and estuarine degradation, and other matters...."

National Ocean Pollution Research and Development and Monitoring Planning Act of 1978 P.L. 95-273

This Act designates NOAA as the lead agency in the development of a comprehensive five-year plan for a Federal program relating to ocean pollution research, development and monitoring. This plan is to provide for the coordination of existing Federal programs relating to the oceans and for the dissemination of information emerging from these programs to interested parties. In addition,

the plan shall provide for the development of a base of information necessary to the utilization, development and conservation of ocean and coastal resources in a rational, efficient and equitable manner.

6.0 FISHERY MANAGEMENT JURISDICTION, LAWS, AND POLICIES

6.1 State Laws, Regulations, and Policies

The directed fisheries for Atlantic sturgeon are conducted within riverine and estuarine areas with the exception of New York, New Jersey, and North Carolina which have in recent years directed small ocean fisheries. Management is by individual State regulations (Appendix 16.2). The primary regulations are minimum fish size and fishing season closures.

6.2 Local and Other Applicable Laws, Regulations, and Policies

There are no known local laws, regulations or policies affecting Atlantic sturgeon.

7.0 DESCRIPTION OF FISHING ACTIVITIES

7.1 History of Exploitation

Gent (1675) described Atlantic sturgeon as so abundant that it was hazardous for small boaters to navigate in some New England rivers. Ryder (1888) stated that the early U.S. Fish Commissions placed heavy emphasis on Atlantic sturgeon, second only to American lobsters as important fisheries at that time. The earliest Atlantic sturgeon information on exploitation is from the mid-1600s. Record keeping of commercial Atlantic sturgeon landings was initiated by the U.S. Fish Commission in 1880. However, landings data until 1967 probably reflect a mixture of both shortnose sturgeon and Atlantic sturgeon. It is believed that the majority of landings consisted of the much larger Atlantic sturgeon. The 1967 Federal endangered species listing of shortnose sturgeon precluded continued landings for that species.

A variety of products were made from sturgeon: the flesh was pickled, smoked, and served fresh; the eggs were salted and sold as caviar; oil was extracted; and isinglass was obtained from the swim bladder and used as a clarifying agent and adhesive. Goode (1887) reported that in 1849, Atlantic sturgeon were valued at 25 to 50 cents each to Maine commercial fishermen. In the first year of that operation, 160 tons were captured. In 1851 only two years later, the business was discontinued because these fish became too scarce. In 1874, a similar activity was undertaken, but after five years, fish again became too scarce to warrant continuation.

In the lower Delaware River between 1825 and 1835, sturgeon sold for 12.5 cents per fish, which was regarded as an expensive fish for that era. In 1873 the meat

sold in New York markets for about 7 cents per lb, these Atlantic sturgeon ranged in weight from about 50 to 100 lb. During this time period, most of the caviar was transported to Germany, where it had a value of $1 per lb (Hoff, 1980).

Cobb (1900), in describing the turn-of-the-century Delaware River sturgeon fishery, reported that in 1897, 978 fishermen, 80 shoremen, and 45 transporters were employed. The salary of the head man of each boat was $45 per month, while other workers received $30. In New Jersey and Delaware, 31 boats valued collectively at $37,150 were used. Cotton drift gill nets, that cost $75 each, were used exclusively. These nets usually had a stretch mesh of 13". They were fished near the bottom on a slack tide. Today, a very similar technique is used except that the nets are made of synthetic materials, mostly nylon.

Reported United States landings have dramatically decreased from about 7 million lb in 1890 to 93,000 lb in 1987 (Figure 1). Imports and domestic aquaculture production are being used to meet the demand no longer filled by domestic fishery production. Commercial aquaculture of the west coast white sturgeon, *Acipenser transmontanus*, provides meat for national markets.

It should not be inferred that these reported historic landings approximated sustainable yields for sturgeon fisheries. It is more likely that these data, depict rapid overexploitation leading to significant depletion. The species is capable of sustaining only very modest rates of annual fishing exploitation.

7.2 Commercial Fishery Activity

Today, there are less than 70 commercial Atlantic sturgeon fishermen in the United States directed riverine fishery, which use gill nets exclusively. The directed commercial fishery for Atlantic sturgeon occurs in New York, New Jersey, Delaware, North Carolina, and Georgia. No sturgeon fishermen rely solely on this fishery for all of their income due to the seasonal nature and low abundance of fish.

Available landing data show that the incidental catch of Atlantic sturgeon far surpasses the directed fisheries harvest. Nearly 77% (1987 data) of the total landings are incidental to other commercial fisheries. Incidental catches of Atlantic sturgeon are taken in a variety of commercial gear, especially otter trawls and gill nets. Shad fisheries, in particular, are responsible for a high number of incidental captures of juvenile Atlantic sturgeon.

A compilation, by State, of sturgeon catches, by gear types, is shown in Table 3.

Table 3. Incidental and directed landings of Atlantic sturgeon, by State and ge for 1987.

	Incidental landings			Directed landings		
State	Gear	Target Species	Weight (lb) All Gear	Gear	Weight (lb) All Gear	No. of Fishermen (Est.)
ME	gill net	lobster bait	909	*	*	*
	trawl	groundfish	*	*	*	*
	gill net	groundfish	*	*	*	*
	trawl		*	*	*	*
NH	gill net	groundfish	761	*	*	*
MA	trawl	groundfish	6,764	*	*	*
RI	*	*	4,246	*	*	*
CT	trawl	groundfish	*	*	*	*
NY	trawl	groundfish	30,500	gill net	7,130	12
	gill net					
	haul seine					
	pound net					
NJ	trawl	groundfish	20,061	*	*	*
	gill net	shad				
	pound net	fin fish				
DE	*	*	*	gill net	170	1
MD	trawl	groundfish	1,103	*	*	*
	gill net	American shad	*	*	*	*
NC	trawl	groundfish	5,341	gill net	8,227	25
	pound net	fin fish	*	*	*	*
	trawl	shrimp	*	*	*	*
	seine	fin fish	*	*	*	*
GA	trawl	shrimp	546	gill net	5,778	25
	TOTALS:	--	70,231	--	21,305	63

* Unknownn

NOTE: Pennsylvania, District of Columbia, Potomac River Fisheries Commissi Virginia, South Carolina, and Florida have closed their Atlantic sturg fisheries. Table does not include New York and New Jersey directed oc fisheries which were identified following the adoption of the FMP.

A detailed description of the directed and incidental landings by State follows:

MAINE

Maine landings of Atlantic sturgeon are by small-mesh anchored gill nets set outside river systems by fishermen directing efforts at fishes used for lobster bait. The groundfish gill netters who use 5.5" stretch mesh nets for cod also take sturgeon. Otter trawls account for the balance of the landings. In 1987, 909 lb of Atlantic sturgeon were landed, down more than 50 % from the 2,198 lb yearly average of the 1980-1987 period.

NEW HAMPSHIRE

The 1980-1987 average annual landings of 188 lb of Atlantic sturgeon were taken by gill net or otter trawl fisheries directed at groundfish.

MASSACHUSETTS

Annual landings of Atlantic sturgeon in Massachusetts by the groundfish fishery averaged 4,608 lb during the past eight years.

RHODE ISLAND

The average annual incidental landings of Atlantic sturgeon for the years 1981-1986 was 4,246 lb. Fish were captured within three miles of the coast and in Nantucket Sound.

CONNECTICUT

There were no reported landings of Atlantic sturgeon in Connecticut during 1980-1987.

NEW YORK

Atlantic sturgeon are landed in New York by directed gill net fisheries in the Hudson River and by incidental catches from marine waters. Most of the incidental catch landings are from groundfish otter trawls. Ocean gill net, ocean haul seine, and pound net fisheries contribute to the incidental harvest that has exceeded the directed harvest since 1984. Table 4. summarizes the incidental and directed harvest for New York during 1980-1987. Preliminary information for 1990 landings indicates a marked increase in excess of 100,000 lb.

Table 4. Recent landings (lb) of Atlantic sturgeon in New York.

Year	Directed	Incidental	Total
1980	14,222	12,300	26,522
1981	7,625	4,000	11,625
1982	13,345	8,500	21,845
1983	16,323	3,600	19,923
1984	10,000	36,300	46,300
1985	15,046	25,300	40,646
1986	9,806	34,100	43,906
1987	7,130	30,500	37,630

NEW JERSEY

Until recently, all landings of Atlantic sturgeon were incidental catches by trawls. Landings of this incidental fishery annually averaged 16,916 lb for the period 1980-1987. Because of increased catches of sturgeon in ocean gill nets, some gill netters have begun directing their gear for them.

DELAWARE

The 1980-1987 average annual landings of Atlantic sturgeon were 859 lb from the lower Delaware Bay and Atlantic Ocean. The American shad drift gill net fishery accounted for the majority of the landings. There is a small directed gill net fishery for sturgeon in the lower Delaware River.

MARYLAND

The average annual catch of Atlantic sturgeon from Maryland waters for the period 1980-1987 was 2,137 lb. There is no information on the proportion of these landings that are incidental to other fisheries, however, they are believed to be primarily from the otter trawl fishery. The pound net and gill net fisheries within the Chesapeake Bay add a small amount to the incidental catch.

NORTH CAROLINA

Directed fishing for Atlantic sturgeon is by gill nets. The annual average (1980-1987) directed landings were 12,928 lb (range: 6,351-31,317). The single largest contributor to the incidental catch was from otter trawls, averaging 13,758 lb annually. Other gear types contributing to incidental landings include pound nets, shrimp trawls, and haul seines. Directed and incidental harvest of Atlantic sturgeon in North Carolina for 1980-1987 is summarized in Table 5.

Table 5. Recent Landings (lb) of Atlantic sturgeon in North Carolina.

Year	Directed	Incidental	Total
1980	8,510	21,502	30,012
1981	9,089	22,393	31,482
1982	10,052	13,315	23,367
1983	6,671	11,306	17,977
1984	31,317	13,632	44,949
1985	6,351	20,594	26,945
1986	10,278	10,281	20,559
1987	8,227	5,341	13,568

SOUTH CAROLINA

The fishery was closed in 1985 following a drastic decline of landings in 1983 and 1984. Juvenile and sub-adult Atlantic sturgeon are still commonly captured incidentally by commercial shad gill net fishermen in both river and near-shore ocean and bays and released as landings are not legal.

GEORGIA

The total annual landings of Atlantic sturgeon in Georgia for 1980-1988 averaged 13,602 lb, of which 98% is derived from the directed gill net fishery. All of Georgia's reported incidental sturgeon catches were from shrimp trawlers, except in 1987 when 230 lb were landed from conch trawling. In the last two reported years, 1987-1988, the average total landings were 6,346 lb, which is only 40% of the average of the previous seven years. Directed and incidental landings of Atlantic sturgeon in Georgia during 1980-1987 are provided in Table 6.

Table 6. Recent landings (lb) of Atlantic sturgeon in Georgia.

Year	Directed	Incidental	Total
1980	14,045	176	14,221
1981	22,310	140	22,450
1982	28,054	69	28,123
1983	10,056	0	10,056
1984	7,290	0	7,290
1985	18,625	38	18,663
1986	8,212	710	8,922
1987	5,778	546	6,324
1988	6,013	354	6,367

FLORIDA

Reported landings for the Florida East Coast were about 1,000 lb annually during 1980-1985. These were almost entirely incidental take.

7.3 Recreational Fishing

There is no significant directed recreational fishery for Atlantic sturgeon in the United States. However, a 1989 article (Donovan, 1989) stated that there is a developing sport fishery for this species in some of the maritime provinces of Canada. Significant restoration of Atlantic sturgeon could result in a directed United States east coast recreational fishery. West coast white sturgeon, *Acipenser transmontanus*, are currently actively pursued in directed sport fisheries in San Francisco Bay and in the Columbia River.

8.0 DESCRIPTION OF ECONOMIC CHARACTERISTICS OF THE FISHERY

8.1 Value

The main economic incentive for directed sturgeon fisheries is to obtain caviar as the demand for this product is high. However, smoked sturgeon (Atlantic, white, and lake) meat, is now more frequently being marketed in the United States. Commercial fishermen received about $50.00 per lb for raw, unprocessed Atlantic sturgeon eggs in 1989. In 1989, United States sturgeon caviar retailed for $235.00 per lb, and Russian beluga caviar was being sold for $683.00 per lb in the Washington, D.C. area.

Atlantic sturgeon have contributed very little to recent total values of Atlantic States' finfish landings because the harvest is so low. Traditionally, much of the meat is shipped to large city markets.

Table 7. shows the landings and values of Atlantic sturgeon for each of the Atlantic coast states during 1970-1987. The wholesale value per lb of sturgeon meat ranged from a high of $2.68 to a low of $0.20 during 1983-1987. West coast white sturgeon meat presently sells for about $4.50 per lb, wholesale. In 1990, smoked sturgeon meat was being sold for $23.00 per lb, retail, in Rockville, MD, a suburb of Washington, D.C.

Table 7. Atlantic Coast Commercial Landings of Atlantic Sturgeon, by State, 1970-1987, (thousands of pounds, and dollars).

Source: National Marine Fisheries Service-1988.

	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	SC	GA 1./	FL (East)
1970	6/*	*/*	2/*	4/*	*/*	14/2	13/2	-/-	4/1	22/4	120/19	6/1	4/1	-/-
1971	1/*	*/*	2/*	5/*	*/*	8/1	12/2	-/-	3/*	17/3	78/13	77/15	4/1	-/-
1972	1/*	*/*	3/*	2/*	*/*	4/1	11/2	-/-	4/1	11/2	154/31	68/18	8/2	-/-
1973	*/*	*/*	2/*	1/*	-/-	4/1	18/3	-/-	8/1	18/3	56/10	45/13	3/1	-/-
1974	*/*	*/*	3/*	3/1	*/*	2/2	10/2	-/-	5/1	9/2	93/16	47/20	2/*	-/-
1975	2/*	1/*	2/*	1/*	*/*	6/1	14/2	-/-	5/1	6/1	44/8	67/23	2/1	-/-
1976	1/*	1/*	1/*	1/*	-/-	4/1	11/2	-/-	2/1	3/1	46/10	88/26	1/1	-/-
1977	5/1	1/*	3/1	1/*	-/-	18/7	12/3	-/-	2/*	5/1	30/5	115/26	3/1	*/*
1978	2/*	1/*	4/1	*/*	-/-	14/6	14/4	*/*	4/1	2/*	32/7	94/31	11/3	1/*
1979	3/1	1/*	1/*	*/*	-/-	19/10	13/4	1/*	3/1	7/2	41/12	79/47	3/1	1/*
1980	3/1	1/*	2/*	1/*	-/-	26/15	10/3	-/-	1/1	3/1	30/11	131/80	14/5	1/*
1981	3/1	*/*	2/1	1/*	-/-	12/4	10/4	2/1	1/*	3/1	31/13	92/53	22/16	1/*
1982	3/1	-/-	2/1	1/*	-/-	22/9	7/2	1/1	1/1	4/1	23/9	100/77	28/20	1/*
1983	2/1	*/*	4/3	2/*	-/-	20/12	17/5	-/-	3/2	4/1	18/12	19/15	10/7	1/*
1984	2/*	-/-	5/1	7/2	-/-	46/21	31/8	-/-	4/2	6/2	45/34	26/26	7/19	*/*
1985	1/*	-/-	7/3	9/4	-/-	41/30	19/9	1/*	2/1	2/*	27/12	15/17	19/49	*/*
1986	2/*	*/-	7/3	8/4	-/-	44/39	20/13	1/*	4/2	-/-	21/14	Closed	9/32	Closed
1987	1/1	1/*	7/3	4/4	-/-	37/27	20/16	-/*	1/1	-/-	14/11	Closed	6/21	Closed

Footnote: -/- = No data available
/ = Less than 500 lb, less than $500.00
1./ = GA dollar figures include caviar from 1985-1987

Example: 14/2 = 14,000 lb, $2,000.00

8.2 Domestic Processing Sector

Processing is usually handled locally by commercial fishermen or small wholesalers. The meat is usually smoked, and the eggs are processed for caviar which has a high value. Smoking of meat is usually done by commercial processors.

Processing techniques for caviar used by South Carolina fishermen include beheading roe fish and removing the tail in the field. The fish are not gutted to avoid getting blood on the eggs. The ovaries are removed from the carcass, sectioned, and placed in a large tub of brine for at least one hour. After this hardening process, the eggs are rubbed through a sieve to separate them from the ovarian tissue. Next, the eggs are passed through an additional brine solution after which they are rinsed, drained, and packaged in jars to sell to dealers (Smith et al., 1984).

Due to the high value of sturgeon caviar, paddlefish, *Polyodon spathula*, are being overexploited as a substitute for sturgeon eggs. Eggs mislabeled as sturgeon caviar are on the market (U.S. Fish and Wildlife Service, Law Enforcement, Southeastern Regional Office, personal communication).

8.3 International Trade

The NMFS reports import and export landings of Atlantic sturgeon under the "miscellaneous" or "other" category from which exact figures cannot be extracted. Such a classification infers an insignificant import/export market for Atlantic sturgeon.

9.0 DESCRIPTION OF THE BUSINESSES, MARKETS, AND ORGANIZATIONS ASSOCIATED WITH THE FISHERY

The directed fishery is conducted by independent fishermen, who do not belong to cooperative associations or labor organizations. There are no known foreign investments in the fishery.

10.0 DESCRIPTION OF SOCIAL AND CULTURAL FRAMEWORK OF DOMESTIC FISHERMEN AND THEIR COMMUNITIES

No commercial fishermen are dependent on Atlantic sturgeon as a sole source of income. Sturgeon landings serve to supplement their income from other fisheries and/or non-commercial fishing sources of income. There are no unique socio-economic aspects of present-day fishermen or their domiciles. There is, however, considerable nostalgia about this fishery, and numerous anecdotal writings exist about how plentiful and large these fishes were before the turn of this century.

Mr. Robert Beck of Port Penn, Delaware, has established a local museum partially devoted to sturgeon. In addition, he has made a color and sound movie film about Atlantic sturgeon fishing that highlights the era just after World War II. For further information about this film, contact Mr. Beck.

11.0 GOAL STATEMENT

The goal of this Plan is to provide a framework for the restoration of Atlantic sturgeon to fishable abundance throughout its range. For the purposes of this FMP, fishable abundance is defined as 10% of 1890 landings of 7 million lb, or 700,000 lb per year. It is not foreseen that current conditions could support Atlantic sturgeon fisheries of the past magnitude. Therefore, the landing level of 700,000 lb per year of adult fish is believed to be an attainable goal. Also, the biology of the species (slow growth and long lived) necessitates a conservative harvest strategy. Although separate stocks may exist, there are no data to permit stock definition, therefore the population is treated as a single stock.

11.1 Specific Management Objectives

The following objectives have been adopted for achievement of the goal:

1. Protect Atlantic sturgeon from further depletion.

2. Improve knowledge of the Atlantic sturgeon stock.

3. Enhance and restore the stock of Atlantic sturgeon.

4. Coordinate Atlantic sturgeon research and management activities throughout the Atlantic coast range.

11.2 Specific Management Recommendations

The following management recommendations, in priority order, are identified as necessary to achieve the goals and objectives of this FMP.

1. Each State should control harvest to increase spawning biomass by adopting either:

    a. A minimum TL of at least seven (7.0) feet (75 inches FL) and institute a monitoring program, with at least mandatory reporting of commercial landings, or

    b. A moratorium on all harvest, or

    c. If a State deviates from the above, the State should submit alternative measures to the ASMFC Atlantic Sturgeon Plan Review Team for determination of conservation equivalency.

2. Each State should identify, characterize, and protect critical spawning and nursery areas.

3. Each State should establish tagging projects to delineate migratory patterns, age and growth, population estimates, and mortality rates.

4. Each State should identify critical habitat characteristics of staging and oceanic areas.

5. The ASMFC should encourage and coordinate a coastwide depository of data and information required to effectively monitor and assess management efforts.

6. The ASMFC should encourage an expanded aquaculture effort to develop techniques to rear Atlantic sturgeon and evaluate hatchery fish for stock restoration.

7. The ASMFC should encourage shortnose sturgeon researchers to also incorporate Atlantic sturgeon into their projects.

8. The ASMFC should encourage determination of environmental tolerance levels (D.O., pH, temperature, river flow, salinity, etc.) for all life stages.

9. The ASMFC should encourage the determination of effects of contaminants on all life stages, especially eggs, larvae, and juveniles.

10. The ASMFC should encourage the evaluation of existing fisheries survey data to aid in determining at-sea migratory behavior and stock composition.

11. The ASMFC should encourage aquaculture research to identify and control early life stage diseases, synchronize spawning times of males and females, and reduce handling stress problems.

12. The ASMFC should encourage the appropriate Federal fisheries management agencies to manage the Atlantic sturgeon fishery in the Exclusive Economic Zone (EEZ).

13. The ASMFC should establish a culture and stocking committee to provide guidance for aquaculture and restoration stocking of sturgeon.

11.3 Justification of Management Recommendations

In jurisdictions where local management agencies deem there is a fishable abundance of Atlantic sturgeon, the FMPs recommendation is to establish a minimum size limit that would allow 50% of females to spawn at least once. This approach would allow for some existing fisheries to continue for larger fish while giving protection to sub-adult fish. Continuing limited fisheries will also help to maintain collection of data on Atlantic sturgeon and keep agencies interested in management and research programs of the species.

Because of severe declines in local Atlantic sturgeon stocks, a number of East coast jurisdictions currently do not allow their harvest. These closures are viewed as being in accordance with the FMPs management recommendations since they allow for maximum protection of the stock where it is most depleted. Presently, the Atlantic sturgeon is being considered by NMFS as a candidate for protection under the Federal Endangered Species Act. Listing of the Atlantic sturgeon as

an endangered species would result in a complete coastwide moratorium of all fishing for the species. The ASMFC feels that this action is unwarranted at this time. Atlantic sturgeon populations remain widespread geographically, with reproducing populations existing in many river systems. A combination of State closures, where necessary, and ASMFC's recommended size limit or equivalent conservation measures of fishable populations should provide adequate protection for Atlantic sturgeon coastwide. Additionally, listing would complicate emerging culture and restoration stocking efforts.

The incidental take of sturgeon in many areas substantially exceeds the directed take. The ASMFC recommends that the member States prohibit the retention and landing of incidentally caught Atlantic sturgeon unless they meet the proposed size limit of at least 7.0' TL (75 inches FL). Additionally, as part of management recommendation #12 (above) Federal fisheries management agencies should be encouraged to adopt similar regulations within the EEZ. No information on the size/sex composition of the incidental sturgeon catch or landings is currently available. Information is also needed on the viability of captured and released sturgeon taken incidentally by nondirected fisheries. Better information on the spawning and nursery habitat requirements of Atlantic sturgeon is also needed. This information is critical for development of regulations to protect these areas from adverse impacts associated with development and for restoration stocking success.

The effectiveness of research and management activities implemented as part of this FMP must be monitored if progress toward the FMPs goal is to be measured. Monitoring of progress could be greatly enhanced by the establishment of a centralized data base. Much of the present data consists of contract reports and other non-published sources that are not easily accessible. A centralized information bank could assemble these data and make it available to all researchers and managers.

The ASMFC feels that it is important to the success of this FMP to enlist the cooperation of appropriate Federal fisheries management agencies in managing Atlantic sturgeon in the EEZ. Effective management of Atlantic sturgeon should include a level of protection within the EEZ equal to that given them by this FMP in State waters.

Aquaculture techniques have been successfully used to enhance other sturgeon species. Prior efforts to artificially spawn Atlantic sturgeon have resulted in difficulties. There is a need to develop new techniques and/or refine existing ones to efficiently spawn and rear Atlantic sturgeon. Once suitable techniques are developed to rear significant numbers of sturgeon fingerlings, trials to asses their stock enhancement potential should be conducted. Research to develop suitable fingerlings should also be accelerated.

The ASMFC believes that a culture and stocking group should be established to develop guidelines for culture and restoration activities to ensure that they are consistent with the goals and objectives of the FMP. This group will be expected to address questions of culture practices, harvest of wild fish for broodstock, evaluation of stock restoration programs, preservation of stock integrity, and disease introduction/spread from non-native sturgeon species. Culture of other sturgeons is progressing rapidly in North America, and now has

commercial applications. Commercial and public cultural activities of non-endemic sturgeons have the potential to negatively impact wild stocks of Atlantic sturgeon through genetic mixing and introduction of diseases if inadvertent releases occur. Such releases should be avoided.

The culture/stocking group would promote information exchange between Federal, State, and private aquaculture programs. This group would report to the ASMFC Advisory Committee's annual Fisheries Management Plan Review Team for Atlantic Sturgeon.

Atlantic sturgeon, Merrimack River, MA (Photo credit: B. Kynard, United States Fish and Wildlife Service).

12.0 A BIOLOGICAL AND FISHERIES PROFILE OF ATLANTIC STURGEON *Acipenser oxyrhynchus oxyrhynchus*

12.1 Identity

12.1.1 Nomenclature

The scientific name for Atlantic sturgeon, is *Acipenser oxyrhynchus* Mitchill. This species consists of two subspecies, the Gulf sturgeon, *Acipenser oxyrhynchus desotoi*, which inhabits the Gulf of Mexico watersheds, and the Atlantic coast subspecies, *Acipenser oxyrhynchus oxyrhynchus*.

Other colloquial names, in addition to Atlantic sturgeon, are: sea sturgeon, common sturgeon, big sturgeon, sharpnose sturgeon, and pelican.

12.1.2 Taxonomy

Class: Osteichthyes - Bony Fishes
Order: Acipenseriformes
Family: Acipenseridae
Genus: *Acipenser*
Species: *oxyrhynchus*
Subspecies: *oxyrhynchus*

The Atlantic sturgeon is one of seven members of the Family Acipenseridae that inhabits the Atlantic, Gulf, Pacific, and certain freshwaters of the United States. There are five members of the genus *Acipenser*, and two members of the genus *Scaphirhynchus* which comprise the seven member Family, Acipenseridae.

Sturgeon are distinctly characterized by having siphon-like protrusible mouth parts, a heterocercal tail, ganoid armor-like plates instead of true scales, and attaining large size and advanced age. The largest reported Atlantic sturgeon was 14′ FL, 811 lb, and 60 years old (Vladykov and Greeley, 1963).

12.1.3 Morphology

The body is fusiform and has five rows of bony scutes: one dorsal, two lateral, and two ventral. The scutes are sharply pointed in young specimens, but become blunt with age. The snout is protruding, and the mouth is subterminal with four barbels in front which extend across most of the width of the snout. Mouth width is less than 55% of the interorbital width; the number of gill rakers is 17-21; postdorsal and preanal shields occur in pairs. Appearance changes considerably with age or size; the snout becomes relatively shorter and blunter, and the lower lobe of the caudal fin becomes relatively longer. Sexes are externally distinguishable only during the spawning season for mature fish when females have swollen abdomens containing ripe eggs. The head is covered with

bony plates. The dorsal and anal fins are opposite, and are situated far posterior (Vladykov and Greely, 1963).

Atlantic sturgeon may be distinguished from shortnose sturgeon by its longer and sharper snout (longer than post-orbital distances), narrower mouth, the width inside the lips less than 3/5 of the interorbital width, with bony plates between the base of the anal fin and the lateral row of scutes. The pigmentation of the lateral scutes is less pale than the background, and the intestines are light in color (Gilbert, 1989).

The Atlantic sturgeon is sympatric with the shortnose sturgeon, *Acipenser brevirostrum*, throughout most of its range and with the lake sturgeon, *Acipenser fulvescens*, in parts of the St. Lawrence River and some other northerly areas. The Atlantic sturgeon has fewer gill rakers and a greater maximum size than the shortnose. Bath and Connor (1981) reported that Atlantic and shortnose sturgeon first become distinguishable from each other when the larvae reach about 0.5" TL.

Atlantic sturgeon and Gulf sturgeon are allopatric, therefore differentiation in the field is not an issue. The most accurate way to separate the two subspecies is by proportional measurements of the spleen to body length. The length of the spleen is 5.7 to 6.0% of fish length in *A. o. oxyrhynchus*, and 12.7 to 17.5% in *A. o. desotoi* (Wooley, 1985).

12.2 Distribution and Movements

12.2.1 General Distribution

Atlantic sturgeon distribution is from Hamilton Inlet or possibly Ungava Bay, Labrador, to the St. Lucie River, Florida (Scott and Crossman, 1973; Wooley, 1985). The Atlantic sturgeon is an anadromous species and is found in the ocean, estuaries, and rivers.

12.2.2 Specific Distribution and Movements

Migrations associated with spawning begin progressively later at higher latitudes (Vladykov and Greeley, 1963). For example, spawning runs begin in February in South Carolina and in May in Maine.

All information in the remainder of this sub-section came from Dovel and Berggren (1983). Movements of adults in the Hudson River, New York were slow, deliberate, and opportunistic with respect to tidal currents, and generally restricted to deeper areas. Adults entered the river from the ocean in the spring to spawn. Adult males usually appeared at the river mouth in early April at water temperatures in the low 40s' (F°), several weeks before the females. Males tended to remain in the river until about October or November. The spawning

males were at least 12 years old, and lengths ranged from 4 to 6.5 ft. Adult females were older (18 years+) and larger (6-8') than males when they first returned to spawn. During spawning, adults were rarely found in waters less than 25' deep. Fish equipped with ultrasonic transmitters moved from side to side of channels, and seldom swam directly against the current. Based on trawl data, mature males possibly were present in the lower estuary for up to 8 months each year during April to November, and females might remain in the estuary for 4 to 6 weeks.

As water temperatures in the Hudson River dropped below 65° F, a mass movement downstream of immature Atlantic sturgeon began. By the time 48° F was reached, young sturgeon that stayed in the river seemed to congregate in deep-water locations where they remained until the spring.

Some immature Atlantic sturgeon left the river entirely. Emigrating fish were at least 1-1/4 years old, but not more than 6 years old. Most emigrants went south along the Atlantic coast in the fall, and probably north in the spring. Tagged Hudson River juveniles have been recaptured between Massachusetts and North Carolina, with a preponderance from Delaware and Chesapeake Bays.

Most of the Atlantic sturgeon present in the Hudson River from December through March were immature fish that congregated in deep areas between the George Washington and Bear Mountain Bridges. The Hudson River is suggested as a primary spawning and nursery area for this species.

A slight rise in water temperature in the spring apparently stimulated immature fish to move upstream from the areas where they congregate in the winter. By mid-April, immature fish moved far upstream. As summer approaches, water temperatures rise to a level that stimulates Atlantic sturgeon to seek deeper, cooler water.

Distribution information by State is presented:

In Maine, remnant populations are now found in the Kennebec, Androscoggin, and Penobscot Rivers. Historically, prior to 1900, Atlantic sturgeon were plentiful in these rivers. It is probable that other river systems such as the Piscataqua, Saco, and St. Croix once had small populations of sturgeon.

In New Hampshire, the Merrimack and Connecticut Rivers once had Atlantic sturgeon, but impassable dams now prevent their entry. The New Hampshire Fish and Game Department has rare reports of sturgeon being caught in the Piscataqua River.

In Massachusetts, sturgeon were previously much more abundant than now. Present knowledge is limited to occasional sturgeon sightings in the lower Merrimack River, commercial landing statistics, and field captures by the Massachusetts Cooperative Fish and Wildlife Research Unit (B. Kynard, Massachusetts Cooperative Fish and Wildlife Research Unit, personal communication).

In Rhode Island, Atlantic sturgeon were reported from Narragansett Bay. There are no reports of them found in any Rhode Island rivers.

In Connecticut, there are occasional reports of Atlantic sturgeon in the Connecticut River as far upstream as Enfield Dam, and in the Housatonic and Thames rivers. During 1988 to 1990, 38 immature Atlantic sturgeon were caught in the Connecticut River. In addition, incidental catches are made by trawlers in Long Island Sound.

In New York, a significant fishery exists for Atlantic sturgeon in the Hudson River as far upstream as Troy, New York. Incidental catches are made in the ocean by trawls, gill nets, haul seines, and pound nets.

In New Jersey and Delaware, Atlantic sturgeon are most abundant in Delaware Bay (river miles 0 to 34) in the spring and in the lower tidal river (river miles 34 to 98) in the summer. This movement pattern is similar to that described for the Hudson River. In Sandy Hook Bay, New Jersey, sturgeon are taken in shad gill and pound nets.

In Maryland, adults migrate up Chesapeake Bay to spawn in freshwater tributaries from late April through May. Juveniles may spend up to four years in the rivers before migrating to the ocean.

In Virginia, Atlantic sturgeon are found in three major rivers tributary to Chesapeake Bay: the Rappahannock, York, and James Rivers.

In North Carolina, Albemarle and Pamlico Sounds, Neuse, and Cape Fear Rivers are the main waters where sturgeon are found. Sturgeon are also found in near shore, ocean waters (<44' deep) from Cape Lookout, North Carolina, to Virginia from late fall through early spring.

In South Carolina, The largest concentration of Atlantic sturgeon is in Winyah Bay and the tributary rivers of the Bay; Santee, Black, Pee Dee, Little Pee Dee, and Waccamaw Rivers. In addition, they are also found in the following South Carolina rivers; Coosawhatchee, Combahee, Edisto, and the Cooper Rivers.

In Georgia, the Altamaha River is the major producer of Atlantic sturgeon, followed by the Ogeechee River. Tagged sub-adults from the Altamaha River have been recaptured as far north as Cape Lookout, North Carolina, and as far south as Mayport, Florida. Harvest also occurs in the Satilla and St. Mary's Rivers.

Florida is the southern most range of the Atlantic sturgeon. They have been captured in the St. Marys, St. Johns, and St. Lucie Rivers. Wooley (1985) reported that during exceptionally cold winters, Atlantic sturgeon move as far south as Port Canaveral and Hutchinson Island.

12.3 Life History

12.3.1 Reproduction

Atlantic sturgeon grow faster and mature earlier in the southern part of their range. Males range between 5 to 24, and females 7 to 30 years old to reach sexual maturity depending upon the geographic location of the stock (Table 8). The interspawning periodicity for females varies from about 2 to 6 years (Smith et al., 1982).

Table 8. Age at first maturity for Atlantic sturgeon by geographic areas.

Investigator	Location	Sex-Age
T.I.J. Smith (1985)	South Carolina	Females--7-19 years (average 10.9) Males--5-13 years (average 8.1)
Dovel and Berggren (1983)	New York	Females--20-30 years Males--11-20 years
Scott and Crossman (1973)	Canada	Females--27-28 years Males--22-34 years

Fecundity is reported as high as 3,760,000 ova per female (Conte, et al., 1988), with a direct relationship between size/age and ova production. In South Carolina, regression based on weight provided a better fit than either length or age for determining fecundity (Smith et al., 1980). They estimated that Atlantic sturgeon weighing 110 and 220 lb would yield over 400,000 and 1,000,000 eggs, respectively.

In Florida, Georgia, and South Carolina spawning migrations usually begin in February; Chesapeake Bay in April; Delaware River in May; Hudson River in April; Gulf of Maine in May; and the St. Lawrence River in May. A fall spawning migration has been reported in some rivers in South Carolina (Smith et al., 1982).

12.3.2 Eggs

Eggs are adhesive and broadcast into flowing water. Ripe, unfertilized eggs measure 0.10" in diameter. They are globular and vary in color from very light to dark brown. At one side, a darker round disk is present, the diameter of the disk is about one-fourth of the circumference of the egg (Ryder, 1888).

Eggs of Atlantic sturgeon hatched in 94 to 168 hours at about 68°F. Under culture conditions, fish grew from 0.3" TL at hatching to 7" TL by day 204. The yolk sac was absorbed in 9 to 10 days after hatching at a length of 0.5", and the larvae then began to show benthic behavior (Smith et al., 1980, 1981).

A reasonable amount of data are available on water temperatures when sturgeon first appear on the spawning grounds, but information on specific spawning temperatures is scarce. Borodin (1925) suggested that sturgeon spawned at 56 to 64°F in the Delaware River. In Maine, sturgeon spawning takes place at about 68°F (T. Squiers, Maine Department of Marine Resources, personal communication). Smith (1985) reported that 55 to 66°F is the temperature range when most fish are captured during their spawning migrations in South Carolina. See Figure 2.

12.3.3 Larvae

Bath and O'Connor (1981) reported observations of sturgeon larvae captured from the Hudson River between 1972 through 1979; this subsection is based on their work. Larvae occurred demersally at depths ranging from 30 to 65', water temperatures ranged from 60 to 78°F, and salinites ranged from 0 to 2.2 ppt.

Yolk-sac larvae are robust, opaque, and dull-brown, with scattered melanophores. A continuous finfold extends from behind the head, dorsally, around the notochord and ventrally, to the posterior end of the yolk-sac. The spiral valve is distinguishable even in small specimens. The mouth begins to develop at 0.3". Gill clefts and rudimentary gills first appear as buds at 0.4". The eye is fully formed at about 0.5". Barbels, buccal morphology, and head shape make the larvae easily identifiable as sturgeon.

At about 0.5", species identification becomes possible. At 0.5", the head has shape and the snout is in a turned-up position. Barbels are developing and finfolds are intact. At 0.6", there are well developed pectoral buds and developing pelvic buds. The caudal fin begins to separate from the dorsal and anal fins, melanophores are more numerous, and teeth begin to show.

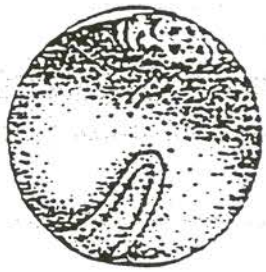
At 1.3", all fins are fully developed, and the dorsal, lateral, and ventral scutes, and nasal openings are easily discernible. The skull is hard and opaque with a pair of longitudinal ridges between the eyes. At about this stage, metamorphosis is complete. See Figure 2.

12.3.4 Juveniles

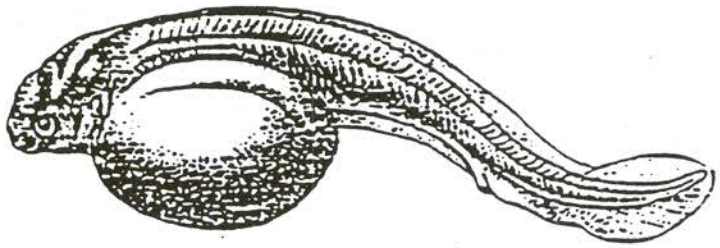
Dovel and Berggren (1983) reported that Atlantic sturgeon grow rapidly during their first three years of life. Most of the annual growth occurs from May to October, with very little growth from October to May. Juveniles attained lengths of about 20" by the third year and 28" by the fourth year. Growth rates declined during the fifth and subsequent growing seasons for juveniles.

Several investigators reported movements of marked juvenile Atlantic sturgeon. In the St. Lawrence River, they moved towards freshwater in the spring, and to saltwater in the fall (Vladykov and Greeley, 1963). In North Carolina, movements were made southward along the coast from November through January, and northward in late winter and early spring. In South Carolina, it was generally concluded that juveniles occupied tidal influenced freshwaters during the warmer months and moved to brackish estuaries during colder periods (Smith et al., 1982).

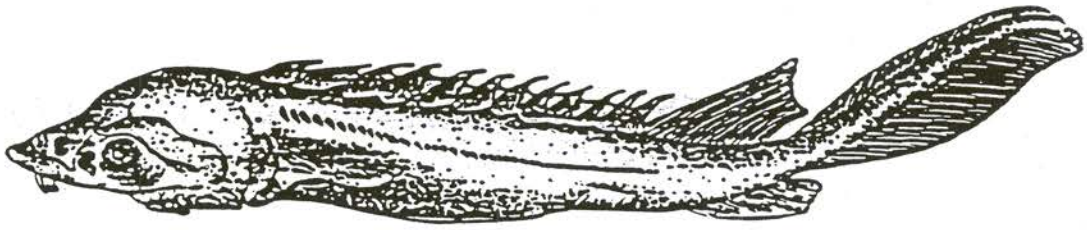
Figure 2. Early life stages of Atlantic sturgeon.



Mature Egg



6 mm larvae



2 months old

(Source: Ryder, 1888).

12.3.5 Adults

Adult Atlantic sturgeon are characterized as long lived, migratory anadromous fish.

12.3.6 Feeding

Atlantic sturgeon adults are omnivorous, benthic feeders. Sturgeon diets in salt water include polychaete worms (e.g. *Nereis viriens*), mollusks, gastropods, shrimp, isopods, amphipods, and some small bottom dwelling fishes such as sand lances *Ammodytes sp.*, (Bigelow and Schroeder, 1953; Vladykov and Greeley, 1963). The diet of young sturgeon in freshwater includes aquatic insects such as mayflies, amphipods, oligochaetes, and some other invertebrates (Van Den Avyle, 1984).

12.4 Population

12.4.1 Structure

There is no fishery independent assessment of the population structure for Atlantic sturgeon.

Data on age/length frequencies are based on samples obtained from commercial fisheries in a few areas (Smith et al., 1984; Dovel and Berggren, 1983; Huff, 1975: See Table 9). These data probably do not accurately characterize actual population structure because of gear selectivity. In most cases, larger mesh sizes are used to selectively target large fish.

Table 9. Reported Atlantic sturgeon total length (feet), by age and sexes combined.

Age (years)	St. Lawrence River[a]	Hudson River[b]	South Carolina[c]	Georgia[d]
0		0.7		
1	0.6		1.7	
5	1.6	2.6	4.0	5.7
10	3.0		5.6	6.5
15	4.0	5.3	6.6	8.0
20	5.3	6.6	7.2	7.9
24	6.6		7.2	
25			7.8	8.8
29		7.8		

a. Hoff (1980)
b. Dovel and Berggren (1983)
c. Smith et al., (1982) converted from fork length calculated TL = 1.09 FL + 3.88
d. Torrey-Ansley (personal communication)

Torrey-Ansley (1989) found that the sex ratio (male:female) of commercially landed Atlantic sturgeon from the Altamaha River, Georgia was 1:1. Smith et al., (1984) reported 1:2-1:4 ratios for South Carolina commercial landings.

Based on South Carolina commercial landings, the mean sizes and ages of females were greater than males. For example, the average size of females was 158 lb versus 88 lb for males, while the mean age of females was 15.5 years as compared to 11.5 years for males (Smith et al., 1984).

12.4.2 Contaminants

Contaminants in Atlantic sturgeon have not been intensively studied. Concentrations of polychlorinated biphenyls (PCB's) in St. Lawrence and Hudson River sturgeon generally exceeded Food and Drug Administration guidelines (5 ppm) for human consumption (Murawski and Pacheco, 1977). The present standard is 2 ppm. More recent limited sampling by the New York Department of Environmental Conservation detected only trace concentrations present in muscle tissue and roe. Slightly higher concentrations were found in brain tissue (R.

Brandt, New York Department of Environmental Conservation, personal communication).

12.4.3 Abundance, Density, and Dynamics

Adult Atlantic sturgeon are seasonally most abundant in rivers during spawning migrations which occur during February to July, depending on latitude. During the remainder of the year, Atlantic sturgeon are captured in estuaries and the near shore ocean.

An assessment of abundance can be determined in three major ways. The first is through population estimates based on mark-recaptures. The second is by population structure size frequency and age. The third method is comparing the amount of landings from year to year. Because of the difficulty in obtaining a large number of Atlantic sturgeon for mark-recapture studies, that information base is very modest.

Dovel and Berggren (1983) conducted a mark-recapture study in the Hudson River, New York. Based on tagging more than 4,000 juveniles, they estimated a population of 100,000 fish (March 1976-March 1977), 60,000 fish (July 1977), and 40,000 fish (October 1977). They attributed the reduction of population size more to emigration than mortality.

Landing statistics vary from year to year depending upon market prices, regulations, and intensity of effort. Therefore, although landings may be an indication of abundance, they are not necessarily a reliable estimate of abundance. Landings during 1930 to 1980 show a very slight downward trend. Reports indicate large upward trends in landings from the Hudson River for 1990 (R. Brandt, New York Department of Environmental Conservation, personal communication).

As indicated earlier in the FMP, in the 1600s there were reports in New England that sturgeon were so dense that they interfered with small boating. They staged at river mouths prior to making their up-river spawning runs. It is likely that the densest concentrations occurred there, at that time, but there is no quantitative information regarding density.

Mortality estimates for Atlantic sturgeon are scarce. However, Huff (1975) reported that annual survivorship of Gulf sturgeon from ages VII through XII was 53.7%.

12.4.4 Community Ecology

The Atlantic sturgeon is a migratory, anadromous fish spending portions of its life in large rivers, estuaries, and the ocean. Much of the species historic riverine habitat has been reduced by dams, degraded by water pollution, and extensive dredging. Diverse benthic community structure is necessary for maintenance of healthy sturgeon populations.

Atlantic and shortnose sturgeon are sympatric in distribution. Little interspecific competition is believed to occur.

12.5 Exploitation

12.5.1 Fishing Gear

The main method used in the directed commercial fishery (New York, Delaware, North Carolina, Georgia) is multifilament drift and set gill nets. The techniques of today are similar to decades ago, except that synthetic material has replaced cotton. Stretch mesh sizes vary from about 5 to 19" depending upon State regulations, traditions, and the size of fish targeted. State gear restrictions are given in Appendix 16.2.

The main commercial gear types (other than gill nets) accounting for the incidental catch are trawls, seines, and pound nets. In New York, about 80% of the 1987 Atlantic sturgeon landings were from trawler incidental take (Table 3). Coast-wide, the 1987 incidental catch exceeded the directed catch by nearly 300% (Table 3).

Recreational hook and line fishing for Atlantic sturgeon is insignificant in the United States. However, an article from the Canadian maritimes indicates an emerging directed sport fishery for Atlantic sturgeon in Canada (Donovan, 1989). In the Pacific northwest, there are directed charter boat sport fisheries for white sturgeon, presumably because of their large size and abundance.

12.5.2 Areas Fished

In New York's Hudson River, deep water areas located outside of the shipping channel are preferred areas for commercial fishing. Gill nets are used with stretch mesh sizes of 12 to 19". In addition, they are caught by other commercial gear in the ocean (R. Brandt, New York Department of Environmental Conservation, personal communication).

In Delaware, Atlantic sturgeon fishing takes place in the lower Delaware River, near Port Penn, about 50 miles upriver from the ocean.

The lower Cape Fear River and the adjacent ocean and the Albemarle Sound area are where the majority of fish are caught in North Carolina.

In Georgia, the Altamaha River supports the State's largest sturgeon fishery with 75% of all participants; drift gill nets are mainly used. Set nets are primarily used in the Satilla, Ogeechee, Savannah, and St. Marys Rivers by about three fishermen per river, each using not more than five nets (Torrey-Ansley, 1989).

12.5.3 Fishing Seasons

In States where legal take is permitted, there is little variation in open seasons (Table 10).

Table 10. Atlantic sturgeon minimum size limits and seasons as reported by States for 1990.

State	Size Limits	Season
Maine	72" TL	Open all year, Except Kennebec and Androscoggin Rivers are closed
New Hampshire	6.0' TL	Mobile gear in ocean waters, open December 15 - April 15
Massachusetts	6.0' TL	Open all year in marine waters
Rhode Island	None	Open all year
Connecticut	48" TL	Open all year
New York	48" TL	Open all year
New Jersey	42" TL, if offered for sale	Open all year
Delaware	54" TL	Open all year
Maryland	25 lb	Open all year
North Carolina	None, except in coastal or joint waters of Cape Fear River where 3' TL is the size limit	Open all year
Georgia	75" FL	February 15-April 15

NOTE: Pennsylvania, District of Columbia, Potomac River Fisheries Commission, Virginia, South Carolina, and Florida have no open season.

12.5.4 Fishing Operations and Results

Historical accounts (1625-1880) indicate that Atlantic sturgeon were extremely plentiful and easily caught (Hoff, 1980; Van Den Avyle, 1984; Gilbert, 1989). The landings record began in 1880 when the U.S. Fisheries Commission started compiling statistical information on commercial fishing landings.

Incidental catches are most often taken by shrimp and groundfish trawls and shad gill nets. The incidental take from the trawl fishery for groundfish in New York in 1987 accounted for approximately one-third (30,500 lb) of the entire Atlantic coast landings (Table 11). In 1987, the coast-wide catch was 91,536 lb, of which the directed catch was 21,305 lb (23%). The most recent (1987) Atlantic sturgeon landing statistics are shown in Table 11.

The landings reported in Table 11 presumably include only legal size fish. The number and size composition of undersized fish caught and discarded by directed and incidental fisheries is unknown.

Table 11. Atlantic sturgeon catch by State and by gear type, 1987.

State	Incidental Landings Gear	Incidental Landings Weight (lb)	Directed Fishery Landing Gear	Directed Fishery Landing Weight (lb)
Maine	Gill net Trawl	909	--	--
New Hampshire	Gill net	761	--	--
Massachusetts	Trawl	6,764	--	--
Rhode Island	Gill net Trawl	4,246	--	--
Connecticut	Trawl	--	--	--
New York	Trawl	30,500	Gill net	7,130
New Jersey	Trawl Gill net Pound net	20,061	--	--
Delaware	0	0	Gill net	170
Pennsylvania	CLOSED		CLOSED	
Maryland	Trawl	1,103	--	--
Virginia	CLOSED		CLOSED	
North Carolina	Trawl Pound Net Haul Seine	5,341	Gill Net	8,227
South Carolina	CLOSED		CLOSED	
Georgia	Trawl	546	Gill Net	5,778
Florida	CLOSED			
	TOTALS	70,231		21,305

-- Unknown

12.6 Social and Economic Implications

12.6.1 Values

United States Atlantic sturgeon commercial landings in 1987 were 91,536 lb, worth 88,004 dollars. The total United States finfish landings for the same year were 6.9 billion lb, worth $3.1 billion. Although Atlantic sturgeon landings comprised only a fraction of one percent of the total landings, the unit value for roe fish is high. Depending upon the caviar yield, a single large, ripe female may be worth $3,000.

Sturgeon fishermen currently receive about $50.00 per lb for unprocessed roe. The April, 1989 retail price for the highest grade domestic sturgeon caviar at a Washington, D.C. area gourmet food store was $236 per lb. Smoked sturgeon meat is scarce. Recent Russian immigrants to New York City have stimulated a demand for fresh and smoked sturgeon in some New York markets. Commercial fishermen who catch Atlantic sturgeon keep some for personal consumption.

Since caviar is a preserved product and has an extended shelf life, market prices are consistent throughout the year.

12.6.2 Employment

About 70 commercial fishermen are engaged part time in this specialized fishery. In addition, there are other employees such as processors of caviar. The total number of people involved part time in this fishery is probably about 100 individuals.

12.6.3 Participation

Participants in the Atlantic sturgeon fishery include fishermen, processors, wholesalers, and retailers. Often, participation in this fishery is a family tradition.

Investment of fishery equipment is believed to be moderate because the only exclusively used equipment are nets that cost up to $1,000 each (A. Magill, National Marine Fisheries Service, personal communication).

12.6.4 Products

There are two major products used for human consumption, flesh and caviar. The more valuable commercial product is caviar, a gourmet food item which is sold primarily in large cities. Gourmet food stores and restaurants are the main retail outlets. In recent years, less expensive roe from other species, e.g. lumpfish, monkfish, and paddlefish have entered the caviar market.

12.6.5 Gear Conflicts

There are some gear conflicts as a result of sturgeon drift gill nets becoming entangled with submerged, anchored gill nets targeting other species. In addition, there are conflicts due to sturgeon drift gill net entanglement with blue crab traps (Clyde Roberts, Port Penn, Delaware, personal communication).

12.7 Management and Protection

12.7.1 Regulatory Measures

The directed fisheries for Atlantic sturgeon are conducted primarily within the internal and State waters (0 to 3 miles) along the Atlantic coast. Therefore, management is by individual State regulations which vary considerably, even between bordering States (Appendix 16.2). There are two main kinds of protection for this species in States which allow harvest: seasons and size limits. However, among States in which harvesting is legal, only Georgia now has a size limit which allows females the opportunity to spawn once before being harvested. Six jurisdictions prohibit sturgeon landings: Pennsylvania, District of Columbia, Potomac River Fisheries Commission, Virginia, South Carolina, and Florida.

Since Atlantic sturgeon are migratory, the inconsistencies in rules among the various States pose special problems. For example, fish protected in one jurisdiction may migrate to other areas where they receive little or no protection. Thus, one States intention to preserve the Atlantic sturgeon stock may be negated by actions in neighboring or other coastal States.

In order to help resolve issues associated with migratory coastal fishes, the ASMFC administers a cooperative program with the NMFS entitled the Interstate Fisheries Management Program. This program provides funding to the Atlantic coastal States to coordinate interjurisdictional fisheries management and develop fishery management plans for species occurring in the territorial sea. FMPs for some coastal migratory species have been developed under the ASMFC program and several States have implemented regulations to comply with these FMPs.

12.7.2 Habitat Protection

The Atlantic sturgeon is extremely dependent on estuaries and their associated freshwater river systems. Both habitats have deteriorated substantially, mainly because of human population and industrial growth. The National Estuary Study (1970) estimated that 73% of the Nation's estuaries have been moderately to severely degraded. Damage and/or destruction has been by dredging and/or filling for waterfront properties, navigation channels, construction of causeways and bridges, installation of ports and marinas, alteration of freshwater flows, and pollution.

Coastal States have enacted coastal zone management laws to regulate dredge and fill activities and shoreline development. The Federal government also has jurisdiction over estuarine habitat. Applicable laws are summarized earlier in

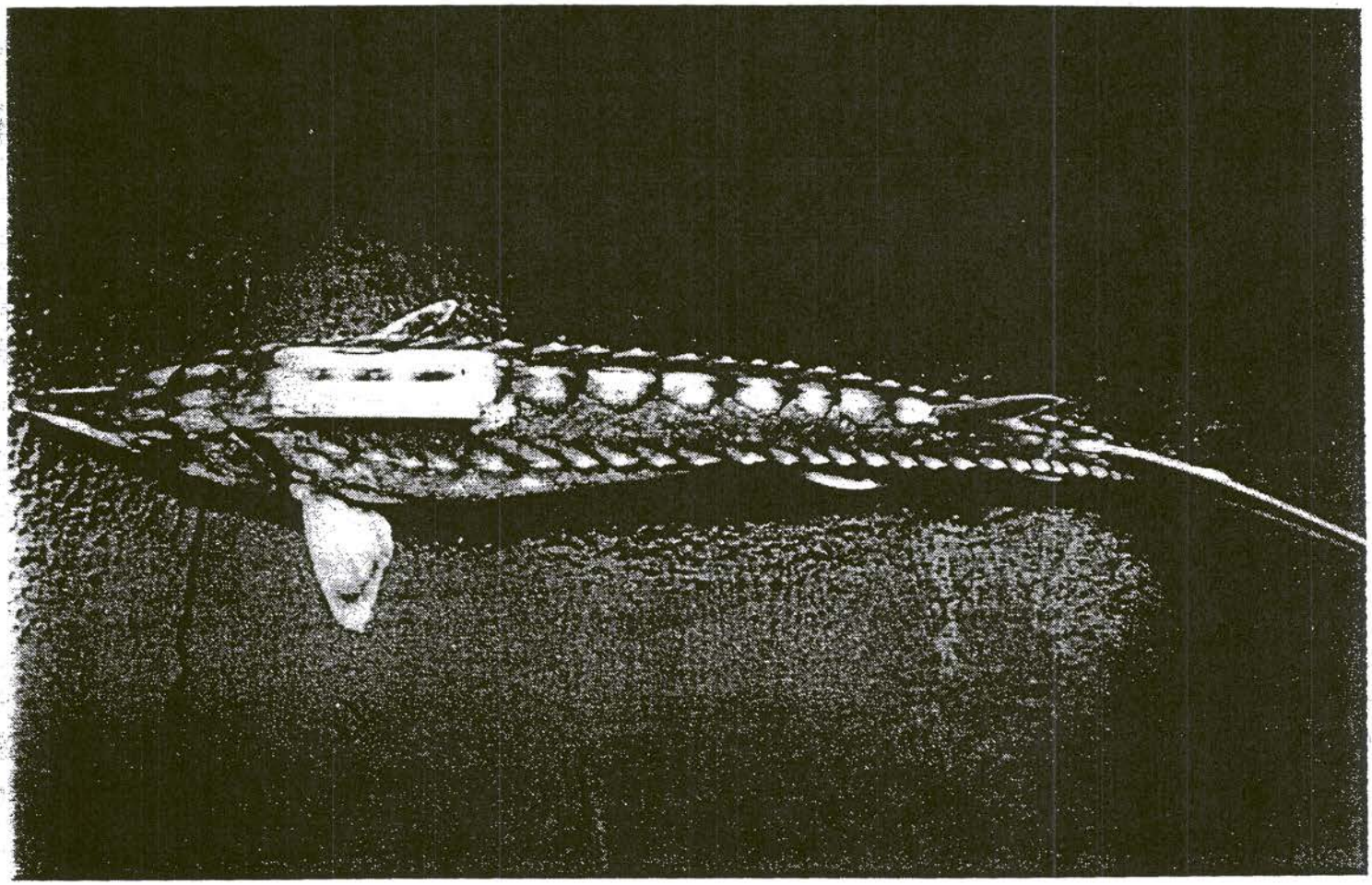
this FMP. The National Oceanic and Atmospheric Administration (NOAA) oversees the Federal Coastal Zone Management Act which is the authority to set standards for approving and funding State coastal zone management programs. The Environmental Protection Agency and participating States may provide protection to fish communities through the National Pollutant Discharge Elimination System permit process for the discharge of pollutants into navigable waters, and the conditioning of these permits to protect valuable resources. The U.S. Army Corps of Engineers and State coastal zone management agencies have jurisdiction of the disposal of dredged material. The Service, under authority of the Fish and Wildlife Coordination Act, reviews and comments on proposals for work and activities in or impacting navigable waters that are sanctioned, permitted, assisted, or conducted by Federal agencies. These reviews focus mainly on potential damage to fish and wildlife, and their habitat. States also review permits for navigable water projects.

12.8 Current Research

Currently, most information on Atlantic sturgeon is collected as incidental data from other fisheries/sampling efforts rather than from directed research activities on this species. For instance, most States conduct routine fish surveys using trawls, gill nets, and seines as well as to provide the monitoring of directed and incidental captures in their States' various commercial fisheries. Information on the size composition and occurrence of sturgeon from such captures and observations is of limited use as these efforts are usually seasonal in nature and often the areas examined are not sites commonly used by sturgeon. However, these data document the presence of sturgeon and give some insight into possible habitat areas and population abundance.

By far, directed research activities provide more useful information of the life history, ecology, population structure, and other aspects of Atlantic sturgeon. In South Carolina and Georgia, efforts are underway to identify and characterize nursery habitat areas as well as to provide information on movements of tagged juveniles. Georgia is also conducting biotelemetry studies with adults and monitoring commercial fishery landings. In addition, Massachusetts, Connecticut, South Carolina, and Georgia currently have programs which are incorporated into related studies with shortnose sturgeon. As Atlantic and shortnose sturgeon have overlapping distributions, such concurrent efforts can be highly productive in collecting information while minimizing costs.

Besides the various State efforts, the Service spawned female Gulf sturgeon in Florida. Although production of juveniles was limited, this work represents a renewed interest in examining the potential for stock enhancement through release of cultured juveniles. The Service entered into a cooperative effort with Georgia in 1990 to propagate Atlantic sturgeon obtained from the Altamaha River. Similarly, a cooperative program between South Carolina and the Service is underway to assess the feasibility of stock enhancement of shortnose sturgeon. To date, approximately 74,000 small juveniles (16 to 70 days old, 0.1 to 1.8" TL) and 2,900 large juveniles (180 to 307 days old; 8.5 to 17.0" TL) have been



Sonic tagged Atlantic sturgeon, Merrimack River, MA (Photo credit: M. Kieffer, University of Massachusetts).

stocked in the Savannah River as part of this effort (Smith and Jenkins, 1989). Information from this project should be applicable to stock enhancement efforts for Atlantic sturgeon.

12.9 Identification of Problems and Research Needs

Historically, and to the present day, management efforts focused on Atlantic sturgeon have been very limited in both scope and duration. This situation is due primarily to two factors: (1) the sturgeon fisheries are of low economic importance to the States and thus of limited interest, and (2) the directed fisheries employ few fishermen and are of a highly seasonal nature (1 to 2 months). However, Atlantic sturgeon supported one of the most lucrative fisheries during colonial days with sturgeon products being highly valued and used domestically and for export.

Today, there are a number of problems impacting Atlantic sturgeon. Due to this species low abundance and low economic importance, fishery administrators are reluctant to allocate their limited funds to the kinds of research needed to allow proper management and restoration of these fish. Further, a cooperative effort is needed among coastal States to manage this common fishery resource but such cooperation cannot usually be elicited without involvement of an interstate jurisdictional organization which has a fishery management plan.

The Atlantic Sturgeon Scientific and Statistical Committee has listed the following research measures, some of which are already included and incorporated in the management measures of this FMP. The Committee reviewed in 1989 the existing information on this species and identified research activities which were needed to aid in the restoration of the stock to fishable abundance. These activities are listed below, unprioritized:

1. Determine size at maturity for mid and north Atlantic sturgeon.
2. Determine stock status in various State rivers.
3. Monitor catch/effort and size/age composition of landings of directed fisheries.
4. Conduct stock identification work.
5. Encourage shortnose sturgeon researchers to include Atlantic sturgeon research in their projects.
6. Establish environmental tolerance levels (D.O., pH, temperature, etc.) for different life stages.
7. Determine effects of contaminants on early life stages.
8. Identify specific critical habitat areas.
9. Evaluate existing groundfish survey data to determine what can be learned about at-sea migratory behavior.
10. Establish coastal tagging projects to delineate migratory patterns.
11. Perform aquaculture research to evaluate the potential for stock restoration/enhancement through the release of cultured fish.

13.0 DESCRIPTION OF STOCK ENHANCEMENT ACTIVITIES

13.1 Early Restocking Efforts

Early culture efforts were begun during the late 19th century in response to the catastrophic declines in sturgeon landings. Detailed studies of sturgeon and the sturgeon fisheries along the Atlantic coast were initiated by John Ryder in 1888 at the suggestion of the U.S. Commissioner of Fish and Fisheries, Marshall McDonald. As a result, Ryder (1888) concluded that, "The only means of maintaining and increasing the industry is through the artificial propagation of this fish, which I have every reason to think may be successfully accomplished at a comparatively insignificant outlay". Later, W. de C. Ravenel, who was in charge of the propagation and distribution of food fishes for the U.S. Fish Commission stated that "There is not a subject in fish culture, excepting the lobster, that we have given more time and thought to in the last few years...We are prepared to do more for the sturgeon than anything else except the lobster" (Stone, 1900). Unfortunately, such enthusiasm was not rewarded with noteworthy tangible accomplishments.

Substantial efforts were focused on spawning Atlantic sturgeon for use in stock restoration efforts, but the task was formidable. The first successful spawning of any North American sturgeon was performed with the Atlantic sturgeon. It was accomplished on the Hudson River in 1875 by Seth Green and A. Marks with the New York State Fish Commission (Harkness and Dymond, 1961). Commercial fishermen, active in the Hudson River fishery, provided live sturgeon to the fishery workers for use in spawning trials. Free flowing eggs were surgically removed from ripe females while milt was either stripped from the males or produced by squeezing excised testes. The eggs and milt were mixed and the fertilized eggs were allowed to attach to cheese cloth, which was then suspended in trays placed in running water. About 40,000 sac fry hatched initially, followed by an additional 60,000 fry the next week.

Based on the foregoing limited success, the U.S. Fish Commission initiated artificial propagation studies with Atlantic sturgeon from the Delaware River in 1888 under the direction of Dr. J.A. Ryder. At the conclusion of his work, he reported "the results were to some extent unsatisfactory, owing to the difficulty of obtaining an abundance of living ova and the difficulties attending their fertilization by artificial means, as well as rearing the embryos...the only ova which I succeeded in fertilizing were obtained from females of the common sturgeon (Atlantic) by cutting open the abdomen of the still living fish. Forcing out the ova by pressure...is not feasible in the case of the sturgeon" (Ryder, 1888).

Ryder's experience identified two major problems which prevented success of the early sturgeon culturists: (1) insufficient supply of simultaneously ripe male and female fish, and (2) fungal infestations of incubating eggs (Dean, 1894; Leach, 1920). The capture of running ripe fish is extremely difficult as spawning occurs in swiftly moving water in deep channels with irregular bottoms. The only successful spawnings occurred when a female was captured near or in the act of spawning and the free-flowing ovulated eggs in the abdomen could be

removed. Instances of such captures were extremely rare. In cases where fertilized eggs were obtained, fungal infection of the eggs by *Saprolegnia* and *Achlya* often occurred and resulted in the total loss of eggs.

Concurrent with efforts on Atlantic sturgeon, spawning attempts were made with other commercially exploited North American sturgeon (e.g. lake sturgeon, *A. fulvescens*, and shortnose sturgeon, *A. brevirostrum*). In general, results and problems were similar to those encountered with the Atlantic sturgeon. By 1912, most culture efforts with sturgeon were halted and thoughts of restocking programs were abandoned.

13.2 Recent Propagation Work

Renewed interest in culture of North American sturgeons began in 1977 in South Carolina. Here, a cooperative State/Service program focused on obtaining life history, ecological, and culture information on Atlantic sturgeon (Smith et al., 1982). In 1979, this species was successfully induced to spawn through injection of acetone-dried sturgeon pituitary glands which were collected from wild-caught fish (Smith et al., 1980). The broodstock were captured in saltwater using gill nets and transferred to an earthen pond containing fresh water. After 12 to 13 days, the fish were used in spawning trials. Some eggs were released in the holding tank either through a non-sutured incision made by the fishermen or through the genital opening. Efforts to strip eggs were largely unsuccessful, so eggs were removed through an abdominal incision. Eggs were mixed with stripped sperm for 1 to 2 minutes before water and diatomaceous earth (to eliminate egg adhesiveness) were added. The eggs were stirred and cleaned for about 20 to 30 minutes and then placed in McDonald hatching jars. At a temperature of about 64°F, hatching began at 121 hours and was completed by 140 hours. During incubation, a fungus (*Saprolegnia*) was observed on the eggs and caused some mortality. The larvae which hatched were reared for up to 131 days, during which time, various culture techniques were tested (Smith et al., 1980).

Several years later, Atlantic sturgeon were again successfully induced to spawn in South Carolina using previously developed techniques (Smith et al., 1981). Survival of fry was initially high, and on day ten, 10,000 fish were stocked into a 0.25 acre pond containing a rich zooplankton bloom. However, shortly afterwards, the pH increased to ≥ 12 and no fish were harvested when the pond was drained. Fish in the laboratory tanks experienced high mortalities, presumably associated with diseases, but no disease organisms were identified (Smith et al., 1981).

Smith et al., (1980) reported that hatchery reared fry were fed a variety of foods, including brine shrimp, beef liver puree mixed with salmon mash, freeze-dried Daphnia, squid pellets, and assorted tropical fish flakes. After the young were 54 days old, a salmon mash diet supplemented with beef liver was fed exclusively.

Several pond and tank rearing trials were conducted from 1978 to 1980 using wild-caught juvenile Atlantic sturgeon in order to obtain information on growth and survival under captive conditions. In tanks, the wild fish would often feed on clam meat, *Mercenaria mercenaria*, beef liver, and chopped squid. However, growth

of these juveniles (weight about 2.2 to 22.0 lb) was usually very slow, and not all fish would eat in the tanks. In fresh water pond culture trials conducted during 1978 to 1980, growth was also minimal and mortality ranged up to 100% depending on water quality conditions (Smith et al., 1981). More recent pond culture trials were initiated in 1985 in brackish water (4 to 20 ppt salinity) ponds at the Waddell Mariculture Center, Bluffton, South Carolina. In this study, 25 wild juveniles (mean size 27" TL, 3.5 lb) were reared for 22 months. At harvest, mean length had increased to 33.5" TL, weight increased to 6.3 lb, and survival was 100% (Smith et al., 1988). Although survival was excellent, their slow growth in ponds would not make it appear feasible to rear wild-caught Atlantic sturgeon juveniles to adult size (~88 lb minimum) under pond culture conditions.

Sub-adult (66 lb) and adult size Atlantic sturgeon (110 to 154 lb) were also held in earthen ponds to obtain information on growth and maturation. Chopped fish, squid, and commercial trout feed were added to the ponds as supplemental food. However, typically within 1 to 2 years, these fish would die, apparently from starvation (Smith et al., 1981). It appears that the ponds did not provide an adequate food base for these large fish and that the supplemental feeding was inadequate even for a maintenance diet. The bottom of the ponds did contain numerous feeding depressions indicating that the fish were attempting to feed.

13.3 Constraints in Stock Enhancement Programs

Stock enhancement efforts with certain North American sturgeons have had some success in recent years. However, substantial constraints must be addressed before an enhancement program for Atlantic sturgeon can be implemented. First and foremost is the identification and collection of a suitable supply of broodstock. From culture studies in South Carolina, it does not appear likely that wild juveniles or sub-adults can be grown to adult size in a reasonable time frame. Further, wild adults cannot be easily maintained in captivity at present. Current stocks of adult sturgeon along the Atlantic coast are severely depressed and spawning areas are poorly defined. Thus, the probability of the simultaneous collection of ripe males and females is low. However, if ripe broodstock were available, the spawning and culture techniques developed for shortnose sturgeon, *A. brevirostrum* and white sturgeon, *A. transmontanus* may be applicable to Atlantic sturgeon (Smith et al., 1985; Conte et al., 1988; Smith, 1990). During 1989, such techniques were used in spawning Gulf sturgeon in Florida; unfortunately, the production of juveniles was limited.

Besides the problem of broodstock acquisition, a number of other areas of concern exist. Such concerns include issues relating to possible homing behavior of cultured fish, movements of juveniles, stock delineation, critical habitats, size at release, and tagging techniques. Such issues need to be addressed before a successful stock enhancement program can be implemented. In South Carolina, the potential for stock enhancement of shortnose sturgeon is being investigated (Smith and Jenkins, 1989). Results of this study should, in part, be applicable to future stocking efforts with Atlantic sturgeon.

13.4 Near Term Recommendations

Of primary importance to future stock enhancement efforts is the protection of the present stock of fish and identification of their spawning areas. In particular, States still having natural spawning migrations of adults need to protect these fish and their spawning areas so that a potential supply of broodstock will be available if and when stock enhancement efforts are initiated.

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15.0 . LITERATURE CITED

Bath, D.W. and J.M. O'Connor. 1981.
Development and identification of larval Atlantic sturgeon, *Acipenser oxyrhynchus*, and shortnose sturgeon, *Acipenser brevirostrum*, from the Hudson River Estuary, New York. Copeia. 1981(3):711-717.

Bigelow, H.B. and W.C. Schroeder. 1953.
Fishes of the Gulf of Maine. U.S. Fish and Wildlf. Serv. Fish. Bull. 74:577 pp.

Borodin, N. 1925.
Biological observations on the Atlantic sturgeon, *Acipenser sturio*. Trans. Am. Fish. Soc. 55:184-190.

Buckley, J. and B. Kynard. 1981.
Spawning and rearing of shortnose sturgeon from the Connecticut River. Progr. Fish - Cult. 43:74-76.

Cobb, J.N. 1900.
The sturgeon fishery of Delaware River and Bay. Rep. U.S. Comm. Fish and Fish. (1899), 25:369-380.

Conte, F.S., S.I. Doroshov, P.B. Lutes, and E.M. Strange. 1988. Hatchery manual for white sturgeon. Coop. Extension. Univ. of Calif., Davis. 103 pp.

Crance, J.H. 1987.
Preliminary habitat suitability indices for Atlantic sturgeon and shortnose sturgeon. Unpublished Report. U.S. Fish and Wildlife Service.

Dadswell, M.J. 1979.
Biology and population characteristics of the shortnose sturgeon, *Acipenser brevirostrum* Lesueur (Osteichthyes: Acipenseridae) in the St. John River estuary, New Brunswick, Canada. Can. J. Zool. 57:2186-2210.

Dean, B. 1894.
Recent experiments in sturgeon hatching on the Delaware River. U.S. Fish Comm. Bull. (1893), 13:335-339.

Dees, L.T. 1961.
Sturgeons. U.S. Fish Wildlf. Serv. Fish. Leafl. 526. 8 pp.

Donovan, M. 1989.
Prehistoric giants offer angling challenge. The Maritime Sportsman. (June, 1989):29-30.

Dovel, W.L. 1979.
The biology and management of shortnose and Atlantic sturgeon of the Hudson River. N.Y. Dept. Environ. Cons. Final Report Proj. AFS-9-R. 54 pp.

Dovel, W.L. and T.J. Berggren. 1983.
Atlantic sturgeon of the Hudson Estuary, New York. N.Y. Fish and Game J1 30(2):140-172.

Gent, J.J. 1675.
An account of two voyages to New England. A description of the country natives, and creatures (reprinted in Coll. of the Mass. Hist. Soc.) 3r Series III. 1833.

Gilbert, C.R. 1989.
Species profiles: Life histories and environmental requirements of coasta fishes and invertebrates (Mid-Atlantic Bight). Atlantic and shortnos sturgeon. U.S. Army and U.S. Fish and Wildlife Service. 28 pp.

Goode, G.B. 1887.
Fisheries and the fishery industries of the U.S. U.S. Department o Commerce. Bureau of Fisheries. Ser.V. Vol. 1.

Harkness, W.J. and J.R. Dymond. 1961.
The lake sturgeon, the history of its fishery and problems of conservation Ontario Dept. Lands and Forests. Toronto. 121 pp.

Hoff, J.G. 1980.
Review of the present status of the stocks of the Atlantic sturgeon *Acipenser oxyrhynchus* (Mitchill). Southeast. Mass. Univ., North Dartmouth Rept. to National Marine Fisheries Service. 136 pp.

Huff, J.A. 1975.
Life history of Gulf of Mexico sturgeon, *Acipenser oxyrhynchus desotoi*, i Suwannee River, Florida. Fla. Mar. Res. Publ. 16. 32 pp.

Leach, G.C. 1920.
Artificial propagation of sturgeon; review of sturgeon culture in the U.S Rept. U.S. Fish. Comm. 1919:3-5.

Leland, J.G., III. 1968.
A survey of the sturgeon fishery of South Carolina. S.C. Wildlife Mar Resour. Comm. Contrib. Bears Bluff Labs. No. 47. 27 pp.

Murawski, S.A. and A.L. Pacheco. 1977.
Biological and fisheries data on Atlantic sturgeon, *Acipenser oxyrhynchu* (Mitchill). U.S. Dept. Commerce. Natl. Mar. Fish. Serv. Northeast Fish Cent. Tech. Ser. Rep. 10. 69 pp.

National Estuary Study. 1970.
Department of Interior Report. Bureau of Sport Fisheries and Wildlife ar Bureau of Commerical Fisheries. 17 vols. Washington, D.C.

Ryder, J.A. 1888.
The sturgeon and sturgeon industries of the eastern coast of the Unite States, with an account of experiments bearing on sturgeon culture. U.S Fish. Comm. Bull. 8:231-326.

Scott, W.B. and M.G. Scott. 1988.
Atlantic Fishes of Canada. University of Toronto Press. 731 pp.

Scott, W.B. and E.J. Crossman. 1973.
Freshwater fishes of Canada. Fish. Res. Bd. Can. Bull. 184. 966 pp.

Smith, T.I.J., E.K. Dingley and D.E. Marchette. 1980.
Induced spawning and culture of the Atlantic sturgeon, *Acipenser oxyrhynchus* (Mitchill). Prog. Fish. Cult. 42:147-151.

Smith, T.I.J., E.K. Dingley and D.E. Marchette. 1981.
Culture trials with Atlantic sturgeon, *Acipenser oxyrhynchus*, in the U.S.A. Jl. World Mariculture Soc. 12:78-87.

Smith, T.I.J., D.E. Marchette and R.A. Smiley. 1982.
Life history, ecology, culture, and management of the Atlantic sturgeon, *Acipenser oxyrhynchus* (Mitchill), in South Carolina. S.C. Wildlf. Mar. Resources, Comm. Final Tech. Rept. AFS-9. 75 pp.

Smith, T.I.J., D.E. Marchette and G.F. Ulrich. 1984.
The Atlantic sturgeon fishery in South Carolina. N. Am. J. Fish. Mgt. 4:164-176.

Smith, T.I.J. 1985.
The fishery, biology, and management of Atlantic sturgeon, Acipenser oxyrhynchus, in North America Envir. Bio. Fish. 14(1):61-75.

Smith, T.I.J., W.E. Jenkins and R.A. Smiley. 1986.
Development of nursery systems for shortnose sturgeon, *Acipenser brevirostrum*. Proc. Ann. Conf. SE Fish Wild Agencies. 40:in press.

Smith, T.I.J., A.D. Stokes, and R. A. Smiley. 1988.
Growth and survival of pond reared juvenile and adult shortnose and Atlantic sturgeon. Jl. World Aquaculture Soc. 19(1): 65.

Smith, T.I.J. and W.E. Jenkins. 1989.
Development of a shortnose sturgeon, *Acipenser brevirostrum*, stock enhancement program in North America. First International Symposium on the Sturgeon. Bordeaux, France. October, 1989. In press.

Smith, T.I.J. 1990.
In Sparks, A.K. (Ed.). Marine farming and enhancement. Proc. 15th U.S. - Japan meeting on aquaculture. 1986. NOAA Tech. Rept. NMFS 85:19-27.

Stone, L. 1900.
The spawning habits of the lake sturgeon, *Acipenser rubincundus*, Trans. Am. Fish. Soc. 29:118-128.

Torrey-Ansley, E. 1989.
Assessment and biotelemetry studies of Atlantic sturgeon in Georgia. Completion report AFC-29. Georgia Dept. Nat. Resources. 77 pp.

Vladykov, V.D. and J.R. Greeley. 1963.
Order Acipenseroidei. Pages 24-59 in Y.H. Olsen, ed. Fishes of the wester North Atlantic. Sears Found. Mar. Res. Yale Univ. 1(3) 630 pp.

Van Den Avyle, M.J. 1984.
Species profiles: Life histories and environmental requirements of coasta fishes and invertebrates (South Atlantic)--Atlantic sturgeon. U.S. Fish an Wildlf. Serv. Biol. Rept. 82(11.25). U.S. Army Corps of Engineers, TR EL 82-4. 17 pp.

Wilk, S.J. and M.J. Silverman. 1976.
Summer benthic fish fauna of Sandy Hook, New Jersey. NOAA. Tech. Rept. NMFS SSRF - 698. 16pp.

Wooley, C.M. 1985.
Evaluation of morphometric characters used in taxonomic separation of Gul of Mexico sturgeon, *Acipenser oxyrhynchus desotoi*. Pages 97-103 in F Binkowski and S.I. Doroshov, editors. North American sturgeon. Development in environmental biology of fishes. Volume 6. Dr. W. Junk Publishers. Th Netherlands.

Wooley, C.M. and E.J. Crateau. 1985.
Movement, microhabitat, exploitation, and management of Gulf of Mexic sturgeon, Apalachicola River, Florida. N. Am. J. Fish. Manage. 5:590-605.

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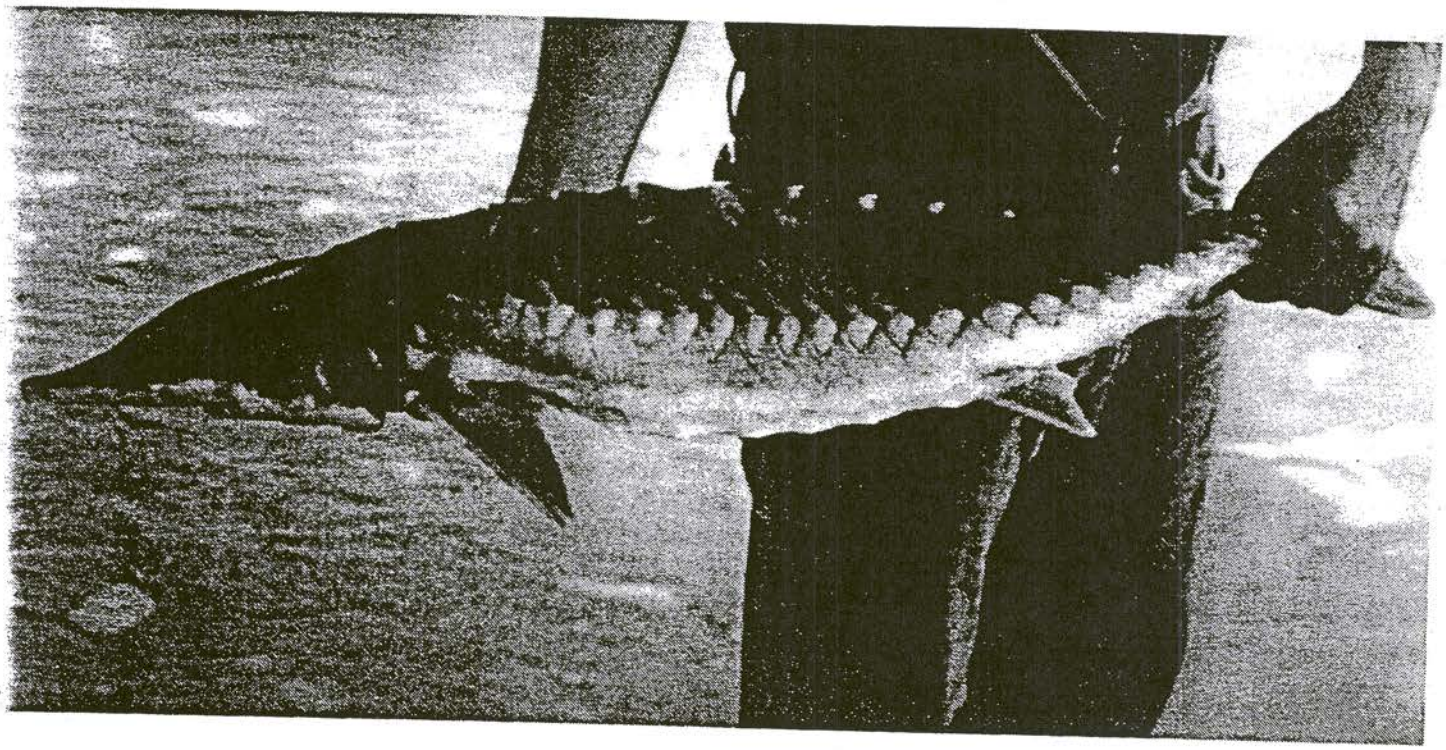

Disc tagged Atlantic sturgeon, Wrightsville Beach, NC (Photo credit: J. Schoolfield, North Carolina Division of Marine Fisheries).

16.2 State Regulations

MAINE

Administrative organization	Department of Marine Resources
Legislative organization	Title 12 Maine Revised Statutes Annotated, Chapters 601-627.
Licenses	Commercial fishing licenses are granted in Maine for commercial harvest of marine and anadromous fish resources within tidal waters. The Department of Inland Fisheries and Wildlife issues commercial fishing permits within inland waters.
Size restrictions	It shall be unlawful for any person to take, catch, destroy or possess any shortnose or Atlantic sturgeon less than 72 " (TL) from the coastal waters of Maine.
Limits	Closed area - It is unlawful for any person to take or catch any sturgeon from the tidal waters of the Kennebec, Androscoggin Rivers, Merrymeeting Bay, and tributaries above a line drawn from the outer extremity of Cape Small to the outer extremity of Salter Island, thence to the outer extremity of Indian Point. No season or numbers restrictions on all other tidal waters of the state.
Gear restrictions	None specific to Atlantic sturgeon. There are gear restrictions in tidal waters which relate to sea herring, menhaden, groundfish and other species which provide some protection to Atlantic sturgeon.
Conservation regulations	The principal spawning and nursery area of the Kennebec and Androscoggin Rivers is closed to the taking of sturgeon.

NEW HAMPSHIRE

Administrative organization	New Hampshire Fish and Game Department
Legislative organization	New Hampshire Code of Administrative Rules RSA 211:62.I
Licenses	Commercial saltwater Resident - $25.50 Nonresident - $200.50 (or equal to nonresident fee in operator's home state)
Size restrictions	No person should take or possess any sturgeon (Acipenseridae) less than 6' (TL).
Limits	None
Gear restrictions	Mobile gear may be used in state ocean waters from December 15 through April 15. No mobile gear may be used to take finfish or crustaceans in the Piscatiqua River or its tributaries north of the Memorial Bridge in Portsmouth. Gill nets must have a 5 1/2 " minimum mesh size.
Conservation regulations	RSA 211:62 I. The rules relating to the taking, inspection, and processing of marine species may be made by the Executive Director of the Fish and Game Department with the approval of the Fish and Game Commission.

MASSACHUSETTS

Administrative organization	Management of fisheries resources in Massachusetts is the responsibility of two separate agencies. Inland Waters - Massachusetts Division of Fisheries and Wildlife. Coastal Waters - Massachusetts Division of Marine Fisheries.
Legislative organization	Division of Fisheries and Wildlife - Massachusetts General Laws, Chapter 131. Division of Marine Fisheries - Massachusetts General Laws, Chapter 130, Section 17A. Actions require approval of the Marine Fisheries Advisory Commission.
Licenses	Permits for commercial fishermen required by the Division of Marine Fisheries.
Size restrictions	Inland Waters - None - No open season for any sturgeon species. Coastal Waters - minimum length 6' (TL) for all sturgeon landed in Massachusetts ports.
Limits	Inland Waters - None - No open season for any sturgeon species. Coastal Waters - None.
Gear restrictions	No general restrictions, but many specific local area coastal seasonal and gear restrictions are in effect to protect other fish species while sturgeon are being taken.
Conservation regulations	None

RHODE ISLAND

Administrative organization	Rhode Island Division of Fish and Wildlife
Legislative organization	Rhode Island Division of Fish and Wildlife, Title 20, General Laws
Licenses	None recreational, commercial license needed for sale.
Size restrictions	None
Limits	None
Gear restrictions	None
Conservation regulation	None

CONNECTICUT

Administrative organization	Connecticut Department of Environmental Protection, Division of Conservation and Preservation, Bureau of Fisheries, Marine Fisheries Program
Legislative organization	Connecticut General Statutes Title 26
Licenses	Resident Commercial Fishing License - $100.00 Nonresident Commercial Fishing License - $150.00 Commercial Landing License - $150.00 (does not allow the holder to fish in Connecticut waters).
Size restrictions	Minimum Length 48" (TL)
Limits	Maximum three fish per vessel per day or trip length, whichever is the longer period of time from Long Island Sound. No sturgeon of any kind may be taken from the inland waters of the State.
Gear restrictions	Several trawl lines established which prohibit trawling within areas.
Conservation regulations	Season and area closures, limitations on species sizes, the gear by which they may be taken, mesh sizes and other restrictions may be managed by regulations after public hearing on proposed changes have been held.

NEW YORK

Administrative organization	New York State Department of Environmental Conservation
Legislative organization	Environmental Conservation Law of New York Section 11 Fish and Wildlife (Inland Waters: Hudson River north of Tappan Zee Bridge) Section 13 Marine and Coastal Resources (Marine Waters: Coastal Waters and Hudson River south of Tappan Zee Bridge)
Licenses	Commercial fishing licenses are required for operation of gill nets in Inland Waters of the Hudson River. A license to sell fish is required in marine waters for all fish offered or exposed for sale or barter. Licenses are issued for operation of sturgeon lines in the Hudson River.
Size restrictions.	Minimum length 48" (TL).
Limits	No catch limit.
Gear restrictions	Hudson River: trawls are prohibited; gill nets prohibited December 1 through March 14. Marine District: numerous area closures restricting use of gill net, trawls and haul seines.
Conservation regulations	No closed season. In the Hudson River from March 15 through June 1 no nets may be set, drawn or allowed to remain in place from 6:00 AM Friday until 6:00 PM Saturday, prevailing time.

NEW JERSEY

Administrative organization	New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife, Marine Fisheries Administration, Bureau of Marine Fisheries
Legislative organization	New Jersey Statutes, Title 23, Chapter 28
Licenses	Drifting Gill Net - $20 per net Staked Gill Net - $3 per net Haul Seine - $25 per net Otter Trawl - $100 per boat
Size restrictions	Marine Waters - 42" (TL) minimum if offered for sale Freshwater - 60" (TL) minimum possession limit
Limits	None
Gear	Tidal freshwater portions of tributaries of Delaware River and Bay: Seine or gill net - minimum mesh - 13" stretch Tidal freshwaters of New Jersey other than Delaware River, its tributaries and tributaries to Delaware Bay: Seine - maximum mesh - 3" stretch maximum length - 70 fathoms Fyke - maximum mesh - 3" stretch maximum leader - 30 fathoms Drifting Gill Net - minimum mesh 5" maximum length - 50 fathoms
Conservation regulations	None

PENNSYLVANIA

Administrative organization	Pennsylvania Fish Commission
Legislative organization	Commonwealth of Pennsylvania, Fish and Boat Code, Act 1980-175, Title 30, Pennsylvania Consolidated Statutes
Licenses	Commercial fishing licenses are granted in Pennsylvania only on Lake Erie waters and for eel chutes, eel pots, and fyke nets only on the Delaware River between the Commonwealth and New Jersey. None are permitted for taking any species of sturgeon.
Size restrictions	None - No open season for sturgeon of any species and their possession is prohibited.
Limits	None - No open season for sturgeon of any species and their possession is prohibited.
Gear restrictions	Special commercial fishing gear restrictions apply on the Delaware River between the Commonwealth of Pennsylvania and New Jersey. Eel chutes can be used to take American eels; and eel pots and fyke nets to take American eels, carp, catfish, and suckers only.
Conservation regulations	No open season for any species of sturgeon in Pennsylvania waters and no possession is permitted except as granted by the Executive Director.

DELAWARE

Administrative organization	Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife
Legislative organization	Title 7, Delaware Code. Chapter 9
Licenses	Commercial food fishing license required to sell fish or use defined commercial gear - $150 Resident, $1,500 Nonresident. Food fishing equipment permit fees in addition to above: haul seine — Resident $25/Net — Nonresident $250/Net hoop net — Resident $10/Net — Nonresident $100/Net fyke net — Resident $30/Net — Nonresident $300/Net gill net — Resident $5/100 yds. — Nonresident $50/100 yds. No new gill net permits will be issued until the number of existing gill net permits is less than 30.
Size restrictions	54" (TL) minimum.
Limits	None
Gear restrictions	None
Conservation regulations	None

MARYLAND

Administrative organization	Maryland Department of Natural Resources, Tidewater Administration, Fisheries Division
Legislative organization	Annotated Code of Maryland, Natural Resources Article Title 4
Licenses	Chesapeake Bay sport fishing license - all finfish in Bay and its tributaries to tidal boundaries -$5 To catch finfish for sale: Nets, seines, trawls, and pots used in ocean but not more than 200 yards of gill net - $100 Nets and seines used in bays but not more than 200 yards of gill net - $50* Hook and line - $25* All gear and more than 200 yards gill net - $125* Fish dealer - $150 * Fees reduced 50% during striped bass moratorium
Size restrictions	Minimum size - 25 pounds
Limits	None
Gear restrictions	Monofilament gill net, otter trawl, beam trawl, trammel net, troll net, drag net and purse seines prohibited (otter and beam trawls are legal on the Atlantic coast of distances of one mile or more offshore). Minimum gill net mesh size restrictions for the area of the Bay and its tributaries north of Bay Bridges and for all spawning rivers and areas - 4". In areas not described above, minimum gill net mesh size 2.5", maximum gill net mesh size 6". Minimum stretch mesh size restrictions for other gears: pound net - 1.5", haul seine - 2.5", and fyke or hoop nets - 1.5".
Conservation regulations	Gill nets prohibited in striped bass spawning reaches.

DISTRICT OF COLUMBIA

Administrative organization	Department of Consumer Regulatory Affairs (DCRA), Housing and Environment Regulation Administration, Environmental Control Division, Fisheries Management Program
Legislative organization	Director, DCRA City Council, District of Columbia
Licenses	None applicable
Size restrictions	A person shall not possess any sturgeon, Shortnose or Atlantic sturgeon (A. brevirostrum and A. oxyrhynchus) on the Potomac River and Anacostia River in the waters of the District of Columbia.
Limits	None applicable.
Gear restrictions	None applicable
Conservation regulations	All fisheries regulations are enacted by the Rulemaking Procedure. The Director of the Department of Consumer and Regulatory Affairs, pursuant to the authority of D.C. Law 5-188, Sec. 4 (a) and Sec. 4 (b), D.C. Code 60923 (1986 Supp.).

POTOMAC RIVER

Administrative organization	Potomac River Fisheries Commission
Legislative organization	Commission composed of members from Maryland and Virginia.
Licenses	None applicable (see below)
Size restrictions	A person shall not possess any sturgeon on the Potomac River.
Limits	None applicable
Gear restrictions	None applicable
Conservation regulations	All regulations are enacted by the PRFC.

VIRGINIA

Administrative organization	Virginia Marine Resources Commission
Legislative organization	Commonwealth of Virginia, Laws of Virginia relating to the marine resources of the Commonwealth, Article 1, Section 28.1-49.1.
Licenses	Gear - specific commonwealth fishing licenses are required. None are permitted for taking any species of sturgeon.
Size restrictions	None. It is unlawful for any person to take, catch, or possess any species of sturgeon.
Limits	None. No gear is licensed for taking any species of sturgeon.
Conservation regulations	It is unlawful for any person to take, catch, or possess any species of sturgeon.

NORTH CAROLINA

Administrative organization	North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries
Legislative organization	North Carolina Administrative Code, Title 15, Chapter 3.
Licenses	Vessels without motors regardless of length when used in connection with other licensed vessels, no license required. Vessels with or without motors not over 18 feet in length, $1/foot. Vessels with or without motors over 18 feet but not over 38 feet in length, $1.50/foot. Vessels with or without motors over 38 feet in length, $3/foot. Vessels owned by persons who are not residents of North Carolina, $200 or an amount equal to the non-resident fee charged by the nonresident's state whichever is greater. Finfish processor - $100. Unprocessed finfish dealer - $50.
Size	None, except in coastal or joint fishing waters of the Cape Fear River in which possession of any sturgeon less than 3' (TL) is prohibited.
Limits	None
Gear restrictions	Trawling for finfish prohibited in internal coastal waters. No purse seine for food fish. No gill nets with stretched mesh size greater than 6" can be used from February 1 through June 30 from Carolina Beach inlet to the South Carolina line.
Conservation regulations	None, except those mentioned above.

SOUTH CAROLINA

Administrative organization	Division of Marine Resources, South Carolina Wildlife and Marine Resources Department
Legislative organization	General Assembly, State of South Carolina, Code of Laws of South Carolina, Section 50, Article 15
Licenses	No specific license for sturgeon fishing, fishery is presently closed.
Size restrictions	None - The season is presently closed and taking and possession of Atlantic Sturgeon is prohibited.
Limits	None - Season closed.
Gear restrictions	Prior to the season closing nets were required to be a minimum stretch mesh of 10".
Conservation regulations	The Marine Resources Division has the authority to set seasons, open areas, size limits and record keeping as required.

GEORGIA

Administrative organization	Georgia Department of Natural Resources
Legislative organization	Official Code of Georgia, Title 27, Article 3
Licenses	Licenses are required for commercial fishing in Georgia, although the applicant is not required to specify the species of fish.
Size restrictions	Minimum size 75" (FL). (7' total length)
Limits	Daily creel limit of 5 fish per person.
Gear restrictions	Gear restriction includes the use of a single net or webbing of mesh not less than 6" on the square, provided that such nets must allow one third of the stream width open for the passage of fish.
Conservation regulations	Commercial sturgeon season is February 15 through April 15.

FLORIDA

Administrative organization	Florida Department of Natural Resources, and Florida Marine Fisheries Commission
Legislative organization	Florida Department of Natural Resources, Chapter 370 Florida Statutes. Florida Marine Fisheries Commission, Chapter 370.027 Florida Statutes.
Licenses	Permits are issued to collect and possess sturgeon for experimental, scientific, educational or exhibitional purposes. Authorized personnel must follow special conditions and restrictions that comply with Chapter 16 R-1 or 16 R-3 Florida Administrative Code.
Size restrictions	NA
Limits	NA
Gear restrictions	NA
Conservation regulations	No open season or fishing allowed for Gulf or Atlantic sturgeon in Florida waters. Chapter 46 - 15 Florida Administrative Code.