THE EARTH'S BEST DEFENSE

Before the Secretary of Commerce

Petition to List Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) as an Endangered Species, or to List Specified Atlantic Sturgeon DPSs as Threatened and Endangered Species, and to Designate Critical Habitat

Source: U.S. Fish and Wildlife Service

September 30, 2009

EXECUTIVE SUMMARY

This is a petition to list *Acipenser oxyrinchus oxyrinchus*, commonly known as the Atlantic sturgeon, as an endangered species throughout all or a significant portion of its range pursuant to the federal Endangered Species Act ("ESA"). In the alternative, the National Marine Fisheries Service ("NMFS") should designate distinct population segments ("DPSs") of Atlantic sturgeon and list each DPS as an endangered or threatened species as specified in this petition.

Atlantic sturgeon date back to the Pleistocene era. They are large, long-lived, slow-maturing anadromous fish. Atlantic sturgeon take 5-19 years to reach sexual maturity in southern waters, and 11-34 years in northern waters. They can live up to sixty years. Females spawn every three to five years, and males every one to five years. Atlantic sturgeon are particularly vulnerable to anthropogenic disturbances due to late onset of sexual maturity, low to moderate lifetime fecundity, intermittent spawning, and sensitivity to chemical toxicity and hypoxia.

Atlantic sturgeon once spawned in as many as 35 rivers in the United States, ranging from Maine to Florida. Historical abundances of spawning adult Atlantic sturgeon reached tens, even hundreds, of thousands in some rivers. Today, spawning subpopulations in nine U.S. rivers have gone extinct. Most of the remaining rivers have spawning subpopulations so depleted that their numbers cannot be reliably estimated and their present day survival is in question. Only two U.S. rivers have surviving subpopulations estimated to be more than 300 spawning adults, and one of these is estimated at only 350 (down 94 percent from estimated historical abundance). Excess (above natural) mortality of ten or more adults annually is considered a threat to the continued viability of Atlantic sturgeon subpopulations numbering less than 300 spawning adults.

Atlantic sturgeon are imperiled by the present and threatened destruction, modification, and curtailment of their habitat and range; by overutilization for commercial, recreational, and scientific purposes; by predation and disease; by the insufficiency of existing regulatory authorities, laws, and policies; and by other natural and manmade factors. Existing stressors that most endanger Atlantic sturgeon survival include bycatch, water pollution, including resulting in reduced dissolved oxygen ("DO") levels or hypoxia, dams, dredging, and ship strikes. Recent studies indicate that global warming is already harming certain Atlantic sturgeon subpopulations and will become an increasingly significant stressor in the future, including by exacerbating harmful hypoxic water quality conditions to which the Atlantic sturgeon are particularly sensitive. Without substantial mitigation and management of these stressors, Atlantic sturgeon are likely to become extinct throughout most of its range.

An Atlantic sturgeon status review team ("ASSRT") convened by NMFS published a status review of Atlantic sturgeon in February 2007 ("ASSRT Report"). The ASSRT determined that multiple stressors threaten the continued survival of Atlantic sturgeon, including bycatch, habitat degradation, water pollution, and ship strikes. The ASSRT recommended ESA listing for certain Atlantic sturgeon subpopulations as delineated into five DPSs: Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic. To date, NMFS has not announced any decision related to the ASSRT Report and to the ESA listing recommendations contained therein.

NMFS should list Atlantic sturgeon as a whole as an endangered species. Atlantic sturgeon as a unitary species is in danger of extinction throughout a significant portion of its range, including the Delaware River, Chesapeake Bay and its tributaries, and many coastal river systems in the Carolinas and the south Atlantic.

In the alternative, NMFS should designate the five DPSs as delineated by the ASSRT as follows:

The Gulf of Maine DPS should be listed as a threatened species because it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range, including as a result of bycatch, dams, dredging and blasting, water pollution, and global warming.

The New York Bight DPS should be listed as an endangered species because it is in danger of extinction throughout all or a significant portion of its range, including as a result of bycatch, water pollution, dredging and blasting, ship-strike mortalities, and global warming.

The Chesapeake Bay DPS should be listed as an endangered species because it is in danger of extinction throughout all or a significant portion of its range, including as a result of bycatch, water pollution, ship strikes, dredging and blasting, poaching, and global warming.

The Carolina DPS should be listed as an endangered species because it is in danger of extinction throughout all or a significant portion of its range, including as a result of bycatch, dams, water pollution, poaching, and global warming.

The South Atlantic DPS should be listed as a threatened species because it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range, including as a result of bycatch, dredging and blasting, dams, water pollution, and global warming.

NOTICE OF PETITION

Hon. Gary Locke
Secretary
U.S. Department of Commerce
1401 Constitution Ave. NW
Washington, DC 20230

Jane Lubchenco
Administrator
Office of the Administrator
National Oceanic and Atmospheric
Administration
1401 Constitution Avenue, NW
Washington, DC 20230

James W. Balsiger
Acting Asst. Administrator for Fisheries
National Oceanic and Atmospheric
Administration
1315 East-West Highway
Silver Spring, MD 20910

PETITIONER:

Natural Resources Defense Council
40 West 20th Street
New York, NY 10011
Tel: (212) 727-2700

The Petitioner Natural Resources Defense Council ("NRDC" or "Petitioner") hereby formally petitions the Secretary of the United States Department of Commerce ("Secretary"),[1] pursuant to 5 U.S.C. § 553(e) and 50 C.F.R. § 424.14, to list Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) as an endangered species under the Endangered Species Act, 16 U.S.C. §§ 1531, *et seq*. In the alternative, Petitioner petitions the Secretary to delineate five DPSs of Atlantic sturgeon as delineated in 2007 by the ASSRT and as described in the attached petition and to list them as follows: the New York Bight, Chesapeake Bay, and Carolina DPSs should be listed as endangered species and the Gulf of Maine and South Atlantic DPSs should be listed as threatened species.

---

[1] Pursuant to the 1974 NMFS-U.S. Fish and Wildlife Service policy, NMFS should be the lead agency reviewing this petition.

Petitioner also requests that critical habitat be designated for Atlantic sturgeon concurrently with listing, pursuant to 16 U.S.C. § 1533(a)(3)(A) and 50 C.F.R. § 424.12.

I. Petitioner

NRDC is a national, non-profit environmental organization with more than 1.2 million members and online activists nationwide, including more than 373,000 members and activists in the Atlantic coastal states. In these Atlantic coastal states, NRDC actively works to improve the management of marine and estuarine resources. NRDC's members regularly visit Atlantic sturgeon habitat for recreational and related purposes, seek to view Atlantic sturgeon in the wild, and are concerned about the decline in their numbers and their risk of extinction. NRDC can be contacted in New York City at 40 West 20th Street, New York, NY 10011, (212) 727-2700.

II. Specific Requested Actions

Petitioner requests that NMFS:

A. List Atlantic sturgeon as endangered.

B. In the alternative, designate five DPSs of Atlantic sturgeon, *i.e.*, Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic; and;

  a. List the New York Bight, Chesapeake Bay and Carolina DPSs as endangered species; and

  b. List the Gulf of Maine and South Atlantic DPSs as threatened species.

C. Designate critical habitat for Atlantic sturgeon and for all identified DPSs.

III. NMFS must issue an initial finding that this petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted."

NMFS must make this initial finding "[t]o the maximum extent practicable, within 90 days after receiving the petition." *See* 16 U.S.C. § 1533(b)(3)(A).

Petitioner need not demonstrate that listing is warranted; rather, Petitioner must only present information demonstrating that such listing may be warranted. While Petitioner believes that the best available science demonstrates that listing Atlantic sturgeon as endangered is in fact warranted, there can be no reasonable dispute that the available information indicates that listing the species as endangered or threatened may be warranted, including because the ASSRT concluded that three of five designated

Atlantic sturgeon DPSs should be listed as threatened; and because NMFS currently lists the Atlantic sturgeon as a candidate species.

NMFS must promptly make a positive initial finding on the petition as required by 16 U.S.C. § 1533(b)(3)(A). Petitioner requests that NMFS make an expedited final finding, since NMFS already conducted a status review of Atlantic sturgeon in 2007.

________________________ Date: This 30th day of September 2009

Bradford H. Sewell
Senior Attorney

TABLE OF CONTENTS

I. INTRODUCTION

In the last decades of the 19th century, Atlantic sturgeon subpopulations in rivers and estuaries along the Atlantic Coast were ravaged by directed fisheries for caviar and flesh. The species has never rebounded. Its life history characteristics—late onset of sexual maturity, low to moderate lifetime fecundity, late maximum egg production, and infrequent spawning— make it inherently vulnerable to what has been an ongoing onslaught of anthropogenic disturbances. A coastwide fishing moratorium was finally put in place in 1998. But this has not proved enough, as it has done nothing to ameliorate the gauntlet of harms, including bycatch in other fisheries, pollution, dams, dredging, and ship strikes, still confronted by Atlantic sturgeon as they traverse coastal waterways and ocean waters. Up and down the coast, in rivers and estuaries where Atlantic sturgeon were once abundant and their spawning runs were once cultural fixtures, Atlantic sturgeon continue to disappear.

In the northeast U.S., aside from small subpopulations persisting in two rivers in Maine, Atlantic sturgeon have been essentially extirpated southward until one reaches New York's Hudson River. Continuing south, the Delaware River, once home to the largest Atlantic sturgeon subpopulation in the U.S., with an estimated over 180,000 adults, is now estimated to have fewer than 300 adult sturgeon left -- a decline of 99.8 percent. While over-harvesting caused the initial collapse a century ago, the remaining number of Atlantic sturgeon in the Delaware has continued to decline rapidly over the last 20 years as a result of bycatch in commercial fisheries, ship strikes, dredging, and water pollution. At the center of the species' historic range, Chesapeake Bay and its tributaries were once home to six spawning subpopulations and the second largest caviar fishery on the Atlantic. Only two subpopulations currently remain, in the James and York rivers, and these are so small they were both believed extinct until recently. Bycatch is currently believed the greatest threat to Chesapeake Bay sturgeon (enough for the ASSRT to recommend ESA listing as threatened on this basis alone) but global warming looms ahead as a significant threat – warming water temperatures will accelerate the growth of hypoxic zones in the bay to such an extent that much of it will likely no longer be hospitable habitat for Atlantic sturgeon, which is considered the most sensitive marine fish species to DO levels. In North Carolina and most of South Carolina, Atlantic sturgeon numbers are estimated to be just three percent of historic levels with no river having more than a tiny relict subpopulation. The second largest Atlantic sturgeon subpopulation in the country, numbering around 350 adults or six percent of historic levels, hangs on in Georgia's Altamaha River. In the remaining rivers in Georgia and northern Florida, decimated by loss of suitable habitat, water pollution, and bycatch, Atlantic sturgeon are believed extinct or estimated at less than one percent of their historic abundance.

One group of scientists, including a leading Atlantic sturgeon expert, put it as follows: "[s]turgeons co-existed with dinosaurs and have survived the cataclysmic ecological effects of asteroid blasts. Why then should we be concerned? The conundrum of sturgeon is that despite their resiliency through evolutionary time, they are particularly sensitive to harvesting and habitat degradation" (Secor *et al.* 2002:3). Of the eight North American species of sturgeon, six species, subspecies and/or DPSs are currently listed and therefore protected under the ESA.[2] Without action to provide similar protection to the Atlantic sturgeon, this enormous prehistoric fish will likely disappear. Secor *et al.* (2002:3-4) warn:

> First, the species becomes commercially extinct; then, sightings of large adults become less frequent, until sightings become so rare that they are written up in the local newspaper. And then, there are none, and the public is prone to forget there were ever sturgeons at all. Such was the experience in Maryland, where no one seemed to notice the disappearance of populations of Atlantic sturgeon in Maryland's portion of the Chesapeake Bay until the 1990s, after nearly a century of slow decline. . . . [T]hey just faded away over several generations of Chesapeake Bay waterman, scientists, and managers. Similar stories of sturgeon population extirpation are now common at the turn of the 20th century.

II. SPECIES ACCOUNT

A. Biology and Status

1. Physical Description

Atlantic sturgeon are large anadromous fish. They have armor-like plates, reach lengths of up to 14 feet, and weigh over 800 pounds. They have a long protruding snout with a ventrally located protruding mouth with four barbels crossing in front (NMFS 1997).

2. Historic Range, Present Range, and Stock Structure

Historic Range

According to the ASSRT (2007: Table 1), Atlantic sturgeon were present historically in approximately 38 rivers in the United States, from the St. Croix in Maine to the Saint Johns River in Florida, and spawned in approximately 35 of them. Atlantic sturgeon were also present and spawned in approximately four river systems in Canada (ASSRT 2007). There is evidence that Atlantic sturgeon were present in Europe during the

---

[2] We note that NMFS also recently determined that the Gulf of Maine DPS of Atlantic salmon should be listed as endangered, determining that "historic salmon populations were several orders of magnitude higher than they are today and occupied a greater diversity of habitats," current productivity is inadequate, and the spatial distribution of the DPS has been severely reduced. NMFS, Final Rule, Endangered Status for the Gulf of Maine Distinct Population Segment of Atlantic Salmon, 74 Fed. Reg. 29344-87 (June 19, 2009) ("Atlantic Salmon GOM DPS Rule") at 29353. The Atlantic sturgeon is currently facing similar circumstances and ESA listing is similarly warranted.

Middle Ages but became extinct there due to recent human activity and climate change (ASSRT 2007).

Present Range

According to the ASSRT (2007), Atlantic sturgeon currently occur in the following U.S. river systems: the St. Croix; Penobscot River; the estuarial system of the Kennebec, Androscoggin, and Sheepscot rivers; Merrimack River; Taunton River; Connecticut River; Hudson River; Delaware River; Susquehanna River; Potomac River; James River; York River; Rappahannock River; Roanoke River/Albemarle Sound; Pamlico Sound/Tar River; Neuse River; Cape Fear-New Brunswick, Winyah Bay/Waccamaw; Great Pee Dee River; Santee River; Cooper River; Ashley River; Ashepoo, Combahee, and Edisto rivers (collectively “ACE Basin”); Sampit River; Savannah River; Ogeechee River; Altamaha River; Satilla River; St. Mary’s River; and St. Johns River. Atlantic sturgeon are also present in approximately 4 rivers in Canada (ASSRT 2007).

The ASSRT (2007: Table 1) determined that Atlantic sturgeon currently spawn in the following U.S. river systems: Kennebec River; Hudson River; Delaware River; James River; Roanoke River/Albemarle Sound; Pamlico Sound/Tar River, Cape Fear-New Brunswick; Winyah Bay/Waccamaw; Great Pee Dee River; Santee River; Cooper River; the ACE Basin; Savannah River; Ogeechee River; Altamaha River; and the Satilla River. Wirgin *et al.* (2007) also found evidence of a spawning subpopulation in York River; the ASSRT (ASSRT: Table 1) listed this river as “possibly” containing a spawning subpopulation.

For certain rivers, the ASSRT (2007) made its determination that spawning is likely occurring based on limited and/or suggestive evidence. Grunwald, *et al.* (2008) believe that, given the difficulty in collecting sturgeon samples from them despite intensive sampling efforts, the spawning subpopulations in the following river systems may be relict sized or extirpated: Pamlico Sound/Tar River, Cape Fear-New Brunswick, Winyah Bay/Waccamaw, Great Pee Dee River, Santee River, and Cooper River. The St. Johns River in Florida now serves only as a nursery area for more northern subpopulations (ASSRT 2007).

In Canada, Atlantic sturgeon are believed to spawn in the Saint Lawrence and Saint John river systems (ASSRT 2007).

Figure 1: Map of Atlantic coast, showing most current or historical spawning rivers for Atlantic sturgeon
Source: Wirgin, *et al.* (2007)

Stock Structure

Atlantic sturgeon exhibit high philopatry to natal rivers and estuaries, which means that individual sturgeon return to spawn where they hatched. This keeps Atlantic sturgeon subpopulations reproductively isolated. Grunwald *et al.* (2008) supports low straying among riverine subpopulations based on significant geographic discontinuities in both mitochondrial DNA (mtDNA) haplotype among maternally derived gene flow (Wirgin *et al.* 2000; Waldman *et al.* 2002, as cited in Grunwald *et al.* (2008)) and estimates of generally less than 1 migrant/generation for microsatellite allelic frequencies (King *et al.* 2001, as cited in Grunwald *et al.* (2008)).

There is a division between northern Atlantic sturgeon subpopulations, which have low genetic diversity but a set of unique haplotypes, and southern subpopulations, which have high diversity and many low frequency, sometimes private, haplotypes. Subpopulations south of the Hudson River displayed high mtDNA diversity as early as the Pleistocene era. Subpopulations from the Hudson River northward later evolved a set of novel haplotypes from modal haplotype A (Grunwald *et al.* 2008).

3. Life History, Longevity and Growth

Atlantic sturgeon life histories vary somewhat based on geographical region. In general, Atlantic sturgeon are long lived, anadromous, late maturing, and dependent on river and estuary habitats for reproduction (ASSRT 2007).

On average, Atlantic sturgeon do not reach 50 percent of maximum lifetime egg production until they are 29 years old, which is 3-10 times later than other bony fish species (ASSRT 2007). Most Atlantic sturgeon do not spawn every year. Females spawn every 2-5 years and males spawn every 1-5 years (ASSRT 2007).

Atlantic sturgeon return to their natal rivers to spawn in fresh water. Males spawn for the first time at approximately 10 years of age, while females spawn for the first time at approximately 15 years of age (Grunwald *et al.* 2008). The time of spawning is dependent on their geographic location. The southernmost subpopulations begin their spawning migration in February-March, while mid-Atlantic populations begin in April-May and the Canadian subpopulations begin in May-July. In the Cape Fear River and south, a fall spawning run occurs in addition to the spring run (ASSRT 2007).

Males usually begin their spawning migration early and leave after the spawning season concludes. Females migrate rapidly upstream to spawn and then immediately return to the marine environment (ASSRT 2007).

Spawning grounds have only been definitively identified for nine of the 35 rivers and estuarine systems that once supported spawning subpopulations. Atlantic sturgeon generally spawn near the fall line, which is the point at waterfalls and rapids where rivers descend abruptly from an upland to a lowland. However, some spawning locations occur above or below the fall line (ASSRT 2007).

Atlantic sturgeon deposit their highly adhesive eggs on hard surfaces on the bottom substrate of rivers and estuaries. The eggs hatch approximately 94-140 hours after being deposited. Larvae remain on the bottom substrate until the yolk sac larval stage is completed, which takes about 8-12 days. The larvae then take 6 to 12 days to move downstream to rearing grounds. During the first half of this migration, they only move at night and use benthic structure (*e.g.*, gravel matrix) as refugia during the day. During the second half of the migration, the larvae are more fully developed and move during both night and day (ASSRT 2007). When they reach a size of approximately 76-92 cm, juvenile sturgeon migrate further downstream into brackish estuarine waters, where they remain for months or years (ASSRT 2007).

The first year of life is extremely important for establishing year-class strength, and Atlantic sturgeon are most sensitive to environmental change during this time. The success of spawning depends on water flow and temperature conditions. Atlantic sturgeon embryos and larvae are vulnerable to sedimentation, fungal infestation, and pollutants, and the young of the year ("YOY") are dependent on the bottom substrate for refuge from predation (Secor *et al.* 2002).

Atlantic sturgeon have been aged to 60 years, but the only age validation study that has been conducted shows variations of ±5 years (ASSRT 2007).

Atlantic sturgeon subpopulations vary in growth rates and ages of maturation. They tend to grow faster and mature earlier in southern systems than in northern systems. In South Carolina, Atlantic sturgeon mature at 5 – 19 years, in the Hudson River at 11 – 21 years, and in the Saint Lawrence River at 22 – 34 years (ASSRT 2007).

4. Habitat

Atlantic sturgeon need large, flowing rivers and estuaries for their reproduction and early life stages. Spawning generally occurs in flowing water between the salt front and fall line of large rivers, with optimal flows of 46-76 cm/s and depths of 11-27 meters (ASSRT 2007). They require hard-bottom and structured habitats to use as spawning substrate and as refuge from predation for their young (ASSRT 2007; Secor *et al.* 2002). Atlantic sturgeon are believed to remain in their natal estuaries until they are two years old. They then move downriver toward more saline regions of the estuaries as they age (Grunwald *et al.* 2008). Dredging, pollution, and low DO levels in rivers and estuaries impair their ability to reproduce and survive until adulthood.

Although Atlantic sturgeon spawn in freshwater, they spend most of their adult life in the marine environment. They move to coastal waters as subadults, with the time of emigration varying among estuaries and cohorts (ASSRT 2007). Once in coastal waters, they stay near shore in shallow (10-50m) water with gravel and sand substrate. Coastal areas where Atlantic sturgeon commonly aggregate in the United States include Massachusetts Bay, Rhode Island, New Jersey, Delaware, Delaware Bay, Chesapeake Bay, and North Carolina (ASSRT 2007).

Once they reach adulthood, Atlantic sturgeon frequently migrate long distances. They have been documented to travel up to 1,450 kilometers (Wirgin *et al.* 2007), and most Atlantic sturgeon cross state and international boundaries (Secor *et al.* 2002). This migration occurs in deep water (ASSRT 2007).

Juveniles and adults tend to remain in marine foraging areas fall through spring and then migrate into estuaries and river systems during the warm summer months in search of thermal refuges (Stein *et al.* 2004).

Atlantic sturgeon use many of the same lower estuary areas as shortnose sturgeon, but have been found to partition space within rivers by water depth and river kilometers, with some overlap (ASSRT 2007).

5. Feeding Habits

Atlantic sturgeon are omnivorous and eat opportunistically. They forage for food in benthic substrate and filter mud with their food. Juveniles eat aquatic insects and invertebrates. When they reach adulthood, their diet expands to include mollusks, gastropods, amphipods, isopods, and fish (NMFS 1997).

6. Recruitment and Natural Mortality

Atlantic sturgeon have limited and often failed recruitment due to environmental factors and mortalities. This impairs their viability because, like all species, their genetic viability depends on subpopulation size and "demographic vigor," which in turn depend on recruitment (Secor *et al.* 2002:5).

Atlantic sturgeon also have a low natural mortality rate. This means that external sources of mortality can significantly affect population growth rates (Secor and Waldman 1999).

7. Population Trends

All 27 species of sturgeons and paddlefish (*Acipenseriformes*) worldwide have suffered dramatic population decline or become extinct over the last hundred years due to direct harvest, habitat alteration, and/or chemical contamination. Atlantic sturgeon populations have suffered similar declines as listed sturgeon species (Grunwald *et al.* 2008). These include the Gulf sturgeon, another subspecies of *Acipenser oxyrinchus*; the shortnose sturgeon, which overlaps in range with the Atlantic and was listed because of many of the same threats confronting the Atlantic sturgeon; and the green sturgeon.

Records indicate that Atlantic sturgeon were very abundant in the mid-1800s (ASSRT 2007). Overharvest resulted in extreme declines in population throughout the 20th century. Atlantic sturgeon have not recovered from these declines, despite the imposition of direct harvest moratoria and various related state regulations and policies (Wirgin *et al.* 2007).

Atlantic sturgeon once spawned in approximately 35 U.S. rivers (ASSRT 2007: Table 1). According to the ASSRT (2007: Table1), Atlantic sturgeon now spawn in approximately 17 U.S. rivers. Evidence of spawning in as many as six of these rivers is very limited and some scientists believe these subpopulations may be relict-sized or extirpated (Grunwald *et al.* 2008). The ASSRT (2007) determined that spawning subpopulations no longer exist in the following U.S. rivers: Merrimack, Taunton, Connecticut, Susquehanna, Potomac, Rappahannock, Sampit, St. Mary's, and St. John's.[3]

The ASSRT (2007:105) noted that "[t]here are only two extant subpopulations with estimates of yearly spawning adults, the Hudson (~860/year) and Altamaha (~350/year). These Atlantic sturgeon subpopulations are suspected to be the largest within the U.S. Therefore, all of the other U.S. subpopulations are expected to have less than 300 spawners per year . . . [for which] the loss of only nine spawners a year could impede the recovery of a subpopulation."

Atlantic sturgeon have already been extirpated in numerous U.S. rivers spanning from Maine to Florida. According to the ASSRT (2007: Table 1), Atlantic sturgeon is no longer known to exist in the Piscataqua River/Great Bay estuary, Pawcatuck River, Thames River, Housatonic River, Nottoway River, Black River, Broad-Coosawatchie, and St. Mary's River.

Trends of extant subpopulations of Atlantic sturgeon in certain individual river and estuary systems are provided below.

Canadian River Systems

Atlantic sturgeon are thought to have once spawned in the Miramichi, Shubenacadie, Avon, Annapolis, St. Croix, and other rivers (ASSRT 2007). Atlantic sturgeon currently spawn only in the Saint Lawrence and Saint John rivers (ASSRT 2007).

Saint Lawrence River

As late as the 1960's, Atlantic sturgeon were abundant downstream of Quebec City and were thought to be spawning below waterfalls on tributaries (ASSRT 2007). One running ripe female and 32 running ripe males were caught and tagged in 1997 and 1998, and tracking showed that they congregated in six different areas in the river (ASSRT 2007). Three of these areas (Richelieu Rapids, Saint – Antoinede-Tilly, and the mouth of the Chaudiere River) were believed to be spawning areas, while the rest were believed to be feeding and resting areas (ASSRT 2007). From 1994-2000, catch per unit effort decreased dramatically at the Kamouraska and Montmagny fishing areas, and 80% of the catch shifted to medium sized fish which indicated poor recruitment (ASSRT 2007). Recent tagging studies and other data suggest a recent increase in spawning and abundance (ASSRT 2007).

---

[3] The ASSRT (2007) also notes reports of historical harvests of Atlantic sturgeon in the Patuxent, Choptank, Nanticoke, and Wicomico/Pocomoke rivers.

Saint John River

Atlantic sturgeon are believed to spawn in the mainstem of the Saint John River and the Kennebecasis, Canan, Grand Lake, and Oromocto tributaries (ASSRT 2007). A large number of juvenile and adult Atlantic sturgeon were captured in sampling efforts during the 1970s, 1980s, and 1990s, and ranged in size from 19 – 480 cm (ASSRT 2007). Currently, approximately 200 – 300 adults are captured each year, but it is not known if these are all Saint John River Atlantic sturgeon or a mix of neighboring populations (ASSRT 2007).

United States River Systems

Penobscot River

The ASSRT (2007) believed it probable that a small spawning subpopulation persists in the Penobscot River. In 2006, seven Atlantic sturgeon were captured in 1004.39 hours of sampling effort. One appears to have been an adult, based on its size (145 cm total length (“TL”)) and time of capture. The possible persistence of a small spawning subpopulation also is supported by archeological evidence and sporadic sightings by fishers (ASSRT 2007).

Kennebec River

Atlantic sturgeon were abundant in the Kennebec River during the nineteenth century, with numbers reaching 10,240 adults prior to 1843 (ASSRT 2007).

From 1977-2000, a gill net survey captured 336 Atlantic sturgeon (nine adults and 327 subadults) in the Kennebec River. In June 2005, a 178 cm TL sturgeon was captured in an American shad gill net in Taconic Bay, just upstream of the meeting of the Sebasticook and the Kennebec rivers (ASSRT 2007). Despite that no eggs, larvae, or YOY have been captured in the last 15 years, the ASSRT concluded that a spawning population exists in the Kennebec River based on the presence of adult male Atlantic sturgeon in ripe condition near the head-of-tide during June and July of 1994, 1997, and possibly in 2005, and the presence of subadults (48 cm to over 100 cm TL) in tidal freshwater tributaries and the mid-estuary and mouth of the Kennebec River from at least April to November.

Hudson River

Prior to 1890, the subpopulation of Atlantic sturgeon in the Hudson River had an estimated 6,000 spawning females (Grunwald *et al.* 2008). This was reduced to approximately 870 spawning adults of both sexes by 1995 (ASSRT 2007). This represents more than an 85 percent decline.

Some of this decline has occurred relatively recently. Atlantic sturgeon reproduction in the Hudson dropped in the mid- to late 1970s and again in the late 1980s (ASSRT 2007). Cornell researchers estimated a wild age-1 Atlantic sturgeon population of 4,313 in 1995, indicating that recruitment was very weak in 1994. When they repeated their sampling in 1996, they caught only eight juvenile Atlantic sturgeon in the age-1 and age-2 year classes. Seven of these were cultured fish. In the 1997 survey, more than 50 percent of the 82 Atlantic sturgeon that they caught were hatchery fish (ASSRT 2007). As reported by the ASSRT (2007:14), recent bycatch records from the Long River Survey and the Fall Shoals Survey indicate that

> [a]bundance of young juvenile Atlantic sturgeon has been declining, with CPUE peaking at 12.29 in1986 (peak in this survey) and declining to 0.47 in 1990. Since 1990, the CPUE has ranged from 0.47-3.17, increasing in recent years to 3.85 (2003). . . . In 2003 – 2005, 579 juveniles were collected (N = 122, 208, and 289, respectively) (Sweka *et al.* 2006). Pectoral spine analysis showed they ranged from 1 – 8 years of age, with the majority being ages 2 – 6. None of the captures were found to be YOY (< 41 cm TL).

Delaware River

The Delaware River subpopulation was historically the largest subpopulation of Atlantic sturgeon, with an estimated 180,000 spawning females prior to 1890 (Grunwald *et al.* 2008). A major Atlantic sturgeon fishery for caviar developed in 1870, and in 1890 over 3350 metric tons of Atlantic sturgeon were landed from coastal rivers, 75 percent of them in the Delaware River fishery. Extreme overharvesting led to rapid depletion of Atlantic sturgeon in the Delaware River. Even as Atlantic sturgeon were diminishing in number in the late 1890’s, close to 1,000 fishers continued to harvest Atlantic sturgeon in Delaware Bay. New Jersey fishers intercepted spawning runs before Atlantic sturgeon were able to reproduce, accelerating their decline (Wirgin *et al.* 2007). The Delaware River fishery for Atlantic sturgeon collapsed by 1901, when less than 10 percent of peak landings were reported. From 1901 to 1920, Atlantic sturgeon landings declined even further to 5 percent of peak landings. In the 1950s, the fishery switched from targeting caviar to targeting flesh, but continued to harvest Atlantic sturgeon (ASSRT 2007).

Due to this overharvesting and subsequently to habitat degradation, ship strikes and bycatch, current Atlantic sturgeon numbers in the Delaware River are greatly reduced from historical levels (ASSRT 2007). The Delaware River subpopulation, once the most abundant of Atlantic sturgeon subpopulations, is now one of the smallest. It has a very small reproducing subpopulation estimated to be fewer than 300 spawning adults (ASSRT 2007, Wirgin *et al.* 2007). Estimates of juvenile abundance between 1991 and 1995 declined dramatically, from a high of 5,600 to fewer than 1,000. Atlantic sturgeon captures in an annual small mesh gill net survey have dropped from 32 fish/effort hr in 1991 to only 2 fish/effort hr in 2004 (ASSRT 2007).

Chesapeake Bay (James and York Rivers)

Commercial landings indicate that the James River Atlantic sturgeon subpopulation was once the most abundant in the Chesapeake Bay. This subpopulation has since declined so dramatically that for a long time it was thought to be extirpated. One 1988 study produced probability estimates of 0.856 and 0.995 that the subpopulation was already extinct (Wirgin *et al.* 2007). Yet some age-0, age-1, and subadult Atlantic sturgeon have been captured in recent years, suggesting that the subpopulation persists (Wirgin *et al.* 2007). Significant haplotype frequency differences indicate that the persisting James River subpopulation is genetically distinct from other Atlantic sturgeon subpopulations (Wirgin *et al.* 2007; ASSRT 2007).

The James River subpopulation is estimated to have fewer than 300 spawning adults (ASSRT 2007).

The York River subpopulation of Atlantic sturgeon is so small and elusive that it was presumed to be extirpated until very recently. Small numbers of age-0 and age-1 individuals were recently collected from the York River, along with a larger number of subadult fish (Wirgin *et al.* 2007). Genetic evidence from these Atlantic sturgeon indicates that a small subpopulation continues to spawn in the York River, as York River Atlantic sturgeon exhibit significantly different haplotype frequencies from other local subpopulations and spawning habitat remains available. Wirgin *et al.* (2007:1226-27) determined that:

> The D2 haplotype that was found in 32% of specimens from the York River was absent from the James River collection and was only detected in a single specimen from the Delaware River and 7% of individuals from Albemarle Sound. This result suggests that the James and York rivers host genetically distinct populations of Atlantic sturgeon. . . . The observation . . . is consistent with genetic results indicating that Atlantic sturgeon exhibit a high degree of philopatry.

The York River subpopulation is estimated at fewer than 300 spawning adults (ASSRT 2007).

Roanoke River/Albemarle Sound

Adults and small juveniles have been captured in this system in recent years, indicating that spawning still occurs. Data from the Albemarle Sound Independent Gill Net Survey indicates that the subpopulation increased between 1990 and 2000, but recruitment has declined dramatically since that time (ASSRT 2007). A gill net survey collected zero to one fish per year from 2001-2003 and 14 fish in 2004 (ASSRT 2007). A 2006 sampling mission by the North Carolina Division of Marine Fisheries Observer (“NCDMF”) Program captured 30 Atlantic sturgeon but only two were YOY (ASSRT 2007).

Although this data indicates spawning persists, the Albemarle Sound subpopulation of Atlantic sturgeon is estimated at less than 300 spawning adults (ASSRT 2007).

Pamlico Sound/Tar and Neuse Rivers

A United States Fish and Wildlife Service (“FWS”) study in 1998 observed two dead juveniles on the bank of Banjo Creek, a tributary to the Pamlico system. The North Carolina Division of Marine Fisheries (NCDMF) Observer Program captured 12 Atlantic sturgeon in Pamlico Sound from April 2004 to December 2005 but none were YOY or spawning adults (ASSRT 2007).

According the ASSRT (2007), there is some evidence of spawning the Tar Neuse rivers, which drains to the sound. A survey in 1980 reported captures of very young juveniles in these rivers. From 2002-2003, North Carolina State University (NCSU) personnel captured four Atlantic sturgeon (561 – 992 mm “fork length” (“FL”) in the Neuse River (ASSRT 2007). In 2005, a juvenile Atlantic sturgeon was captured in each of the Tar and Neuse rivers, indicating possible spawning in those rivers (ASSRT 2007).

Cape Fear River

Atlantic sturgeon abundance in the Cape Fear River is highly uncertain. Survey data suggests an increase in numbers between 1997 and 2003, but the numbers appear to be skewed by an atypical increase in survey results for 2002 (ASSRT 2007). In 2003, the NCDMF collected 91 Atlantic sturgeon (427 – 1473 mm FL) in the Cape Fear River (ASSRT 2007). The spawning population is assumed to be fewer than 300 adults (ASSRT 2007).

There may be two spawning seasons in the Cape Fear River, as adult Atlantic sturgeon have been observed migrating upstream in the fall as well the spring. The fall migrations may instead suggest that some adult sturgeon overwinter upstream (ASSRT 2007).

Winyah Bay/Waccamaw River/Great Pee Dee River

In 2004, two sub-adult Atlantic sturgeon were captured in Winyah Bay during 4.2 hours of gillnet sampling for shortnose sturgeon (ASSRT 2007).

The ASSRT (2007:21) reported some evidence of Atlantic sturgeon presence and possibly spawning in the Waccamaw River:

> Captures of age-1 juveniles from the Waccamaw River during the early 1980s suggest that a reproducing population of Atlantic sturgeon may persist in that river, although the fish could have been from the nearby Great Pee Dee River . . . In 2003 and 2004, nine Atlantic sturgeon (48.4-112.2 cm FL) were captured in the Waccamaw River during the SC Department of Natural Resources (SCDNR) annual American shad gill net survey, although none were considered spawning adults or YOY. However, Collins *et al.* (1996) note that unlike northern populations, in South Carolina, YOY are considered to be less than 50 cm TL or 42.5 cm FL, as growth rates are greater in the warmer southern waters…. Therefore, the capture of a 48.4 cm FL sturgeon provides some evidence that YOY may be present in the Waccamaw River and some evidence of a spawning subpopulation. Lastly, watermen on the lower Waccamaw . . . have observed jumping sturgeon, which suggest[s] that [it] either serve[s] as a nursery/feeding habitat or support[s] an extant subpopulation.

In the Great Pee Dee River, the spawning subpopulation was considered extinct until recently. Subadults and adults were frequently observed, but without any evidence of spawning. Then, in 2003, a fishery survey captured a running ripe male and observed other large sturgeon possibly engaged in a fall spawning run (ASSRT 2007). Fishermen have also seen jumping Atlantic sturgeon on the Pee Dee River, suggesting that an extant spawning population remains or that the river serves as a nursery and feeding ground (ASSRT 2007).

Santee and Cooper Rivers

The ASSRT (2007) found some evidence that small spawning subpopulations persist in these rivers. In 1997, a study captured 151 subadults including some age-1 juveniles. In the winter of 2003, four juvenile Atlantic sturgeon (360 – 657 mm FL) were captured in the Santee (1) and Cooper (3) rivers. A 2004 survey captured 15 subadults in the Santee estuary during 15.6 hours of effort (ASSRT 2007).

Ogeechee River

According to the ASSRT (2007), Atlantic sturgeon are present in the Ogeechee River, but age-1 fish are completely absent during some years and the remaining stock has an unbalanced age structure. This suggests that the subpopulation is “highly stressed” (ASSRT 2007:23). Sampling efforts between 1991 and 1998 had difficulty capturing any age-1 juveniles, indicating spawning or recruitment failure (ASSRT 2007). The Army’s Environmental and Natural Resources Division at Fort Stewart, GA, collected 17 YOY Atlantic sturgeon in 2003 and 9 YOY in 2004. No YOY Atlantic sturgeon were captured in the Ogeechee between 2004 and 2007 (ASSRT 2007).

Satilla River

The ASSRT (2007:24) described the Satilla River Atlantic sturgeon subpopulation as "highly stressed." Only four spawning adults or YOY have been captured since 1995 (ASSRT 2007). It is assumed that there are fewer than 300 spawning adults left (ASSRT 2007).

Savannah River

The Savannah River supports a small reproducing subpopulation of fewer than 300 adults. Since 1999, 70 Atlantic sturgeon have been captured, 22 of which were YOY. In late summer 1997, a running ripe male was captured at the base of the Augusta dam (ASSRT 2007).

Altamaha River

The Altamaha River was the centerpiece of the nineteenth century sturgeon fishery. It still appears to support the largest subpopulation of Atlantic sturgeon in the southeast, but its numbers have been reduced by 94 percent to an estimated 370 spawning adults (ASSRT 2007). Capture numbers are variable (ASSRT 2007).

ACE Basin

Both YOY and spawning adult Atlantic sturgeon are regularly captured in the ACE Basin, which includes the Ashepoo, Combahee, and Edisto rivers. A small spawning subpopulation of fewer than 300 adults is assumed to survive (ASSRT 2007).

B. Distinct Population Segments

For vertebrate species, the ESA defines species to include "distinct population segments" or DPSs. *See* 16 USC § 1532 ("species" defined to include a "distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature"). To determine the existence of a DPS, NMFS considers the "1) discreteness of the population segment in relation to the remainder of the species or subspecies to which it belongs; [and] 2) the significance of the population segment to the species or subspecies to which it belongs." *See Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act,* 61 Fed. Reg. 4722, 4724 (Feb. 7, 1996) ("*DPS Policy*").

A population segment is considered "discrete" if it is "markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation." *See, e.g., Northwest Ecosystem Alliance v. United States Fish & Wildlife Serv*., 475 F.3d 1136, 1150 (9th Cir. 2007). The meaning of markedly in this context is "appreciably." *See Nat'l Ass'n of Home Builders v. Norton*, 340 F.3d 835, 851 (9th Cir. 2003). Appreciably, in turn, means "capable of being perceived or measured." *See Merriam-Webster Online Dictionary* (2009).

A population segment is considered significant based on: 1) "persistence of the discrete population segment in an ecological setting unusual or unique for the taxon," 2) "evidence that loss of the [DPS] would result in a significant gap in the range of a taxon," 3) "evidence that the [DPS] represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range, or" 4) "evidence that the [DPS] differs markedly from other populations of the species in its genetic characteristics." *See Home Builders*, 340 F.3d at 851. These factors are non-exclusive; if any one factor is satisfied, a discrete population must be considered significant. *See Maine v. Norton*, 257 F. Supp. 2d 357, 388 (D. Me. 2003). A "gap in the range of a taxon" is defined as "empty geographic space in the range of the taxon." *Home Builders*, 340 F.3d at 846 (upholding FWS' "gap in the fence" interpretation as reasonable). A gap maybe be considered if it would "decrease the genetic variability of the taxon," substantially reduce the current geographical or historical range of the taxon, result in a gap at the edge of the species range, or cause the loss of a population that is numerous and a large percentage of total taxon members. *See id.*

If a population segment is discrete and significant, then it is a distinct population segment and must be evaluated for endangered and threatened status. It "may be appropriate to assign different classifications to different [DPSs] of the same vertebrate taxon." DPS Policy at 4724.

1. If NMFS Does Not List Atlantic Sturgeon as a Whole as Endangered, NMFS Should Designate the Five DPSs Identified by the ASSRT

If NMFS does not list Atlantic sturgeon as a whole as endangered, the agency should designate the five DPSs of Atlantic sturgeon identified by the ASSRT (2007): Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic. These DPSs are shown in Figure 2 (from ASSRT (2007)) and are described as follows:

> **Gulf of Maine DPS:** River systems in this DPS include Penobscot River; Kennebec, Androscoggin, and Sheepscot rivers estuarial complex; and Merrimack River.
>
> **New York Bight DPS:** River systems in this DPS include Taunton River; Connecticut River; Hudson River; and Delaware River.

> **Chesapeake Bay DPS:** River systems in this DPS include York River; James River; Rappahannock River; Potomac River; Susquehanna River, and Nanticoke River.
>
> **Carolina DPS:** River systems in this DPS include Roanoke River/Albemarle Sound; Pamlico Sound/Tar and Neuse rivers; Cape Fear River; Winyah Bay/Waccamaw, Great Pee Dee, and Sampit rivers; Santee River; and Cooper River.
>
> **South Atlantic DPS:** River systems in this DPS include ACE Basin (Ashepoo, Combahee, Edisto rivers); Savannah River; Ogeechee River; Altamaha River; Satilla River; St. Mary's River, and St. John's River.

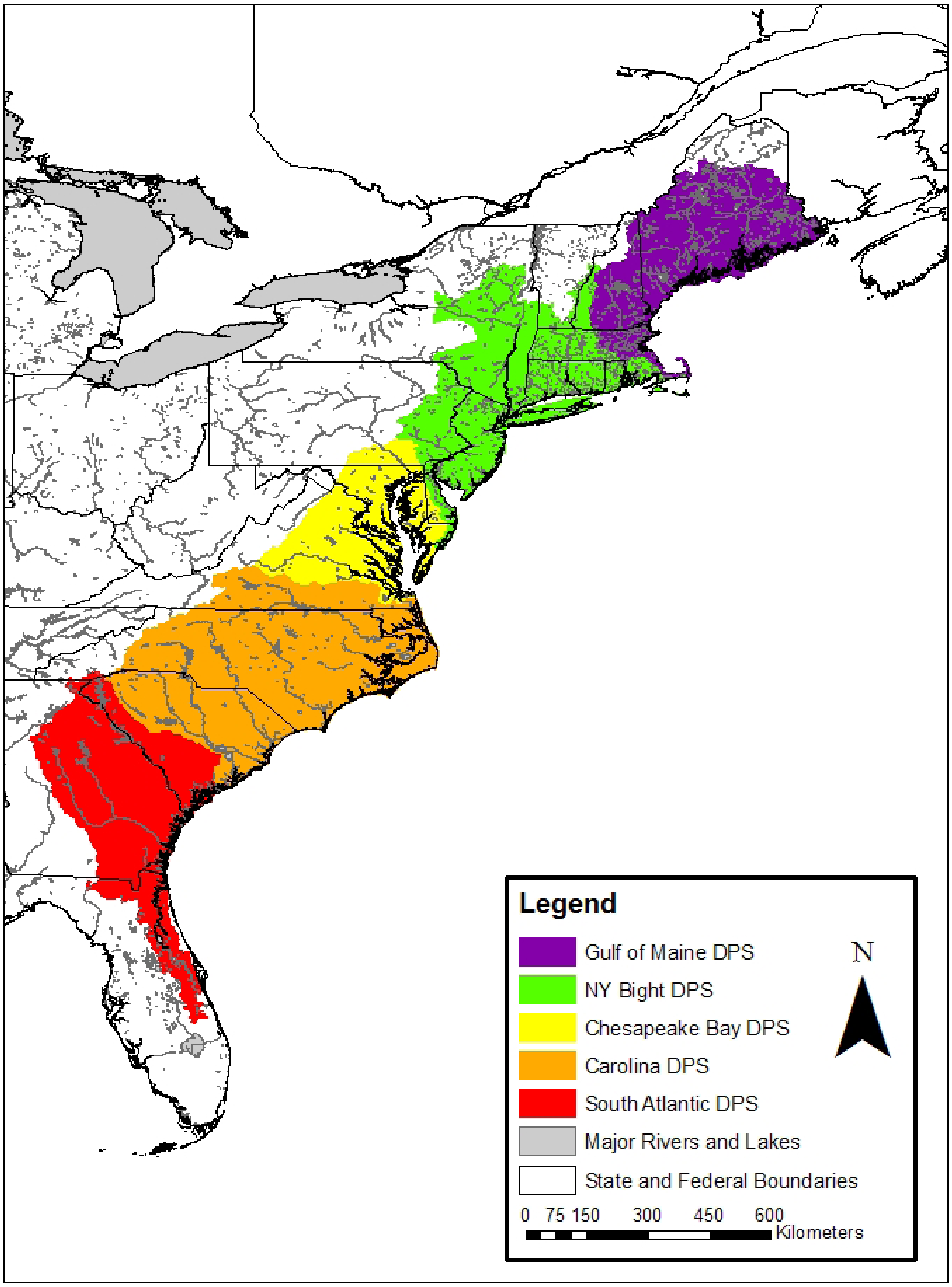
These five DPSs are discrete pursuant to the ESA because genetic data allows for 94% accuracy in tracing an individual Atlantic sturgeon to these DPSs, and because these DPSs have developed differentiated spawning behavior and timing (ASSRT 2007). Indeed, the ASSRT (2007:28 (emphasis added)) found it "reasonable to conclude that all of the U.S. Atlantic sturgeon subpopulations could be considered discrete subpopulations" based on the fact that "Atlantic sturgeon are 1) physically separated from other subpopulations during the spawning season, 2) genetic analysis suggests that each subpopulation is statistically significant[sic] different from one another using both mtDNA and nDNA markers and multiple genetic analysis, and 3) migration behaviors of Atlantic sturgeon both as adults and developing larvae vary among river systems." An Atlantic sturgeon's natal river can be determined with 88% accuracy using genetic testing, and the different subpopulations have generally adapted to the unique ecological features of their watersheds by developing distinguishable behavioral and physiological traits (ASSRT 2007).[4]

The ASSRT (2007) concluded that these 5 DPSs are significant pursuant to the ESA because "Atlantic sturgeon are 1) found in five unique ecological settings, 2) genetic analyses suggest that subpopulations can be easily grouped into five populations with high certainty and these groupings correlate well with the five unique ecological settings, and 3) due to low gene flow among populations, the loss of one or more [of] these five populations could negatively impact the species as a whole" (ASSRT 2007:29*)*. Since there is little gene flow among subpopulations from different rivers and estuaries (ASSRT 2007), the loss of even a single subpopulation will result in the removal of a section of the species' range where it has been viable and will thereby reduce genetic diversity of the taxon as a whole. This is especially significant given the expected changes in climate and habitat due to global warming. The ability of Atlantic sturgeon to adapt to climate change depends on genetic and geographic diversity, as maximum gene variation increases the odds that genes will carry traits amenable to climate change adaptation, such as for thermal tolerance (Gephard, ND).

---

[4] River-specific DPSs have been identified for other fish species, including the shortnose sturgeon and chinook salmon (NMFS 1998).

Figure 2: U.S. range of Atlantic sturgeon showing proposed five DPSs
Source: ASSRT (2007)



III. THE ATLANTIC STURGEON SATISFIES THE STATUTORY CRITERIA FOR LISTING AS ENDANGERED AND/OR THREATENED SPECIES

To determine whether a species is endangered or threatened, NMFS must consider five statutorily prescribed factors:

> (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence.

16 USC § 1533(1)(A)-(E). The agency "must consider each of the listing factors singularly and in combination with the other factors." *Carlton v. Babbitt*, 900 F. Supp. 526, 530 (D.D.C. 1995). "Each factor is equally important and a finding by the Secretary that a species is negatively affected by just one of the factors warrants a non-discretionary listing as either endangered or threatened." *Nat'l Wildlife Fed. v. Norton*, 386 F. Supp. 2d. 553, 558 (D. Vt., 2005) (citing 50 C.F.R. § 424.11(c)). Likewise, a species must be listed if it is endangered or threatened because of "a combination of" factors. *See, e.g.*, 50 C.F.R. § 424.11(c).

The biology of Atlantic sturgeon -- including their late onset of sexual maturity, low to moderate lifetime fecundity, maximum egg production at a late age, intermittent spawning, and their relatively high sensitivity to chemical toxicity and hypoxia -- makes them particularly sensitive to anthropogenic disturbances (Wirgin *et al.* 2007). According to the ASMFC (2007b:5), "[t]o remain stable or grow, populations of Atlantic sturgeon can sustain only very low anthropogenic sources of mortality (< 4% per year)." The factors threatening the continued survival of this highly vulnerable species are detailed below.

A. Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

Secor *et al.* (2002:5) described the significant threat that past and ongoing habitat harm poses to the Atlantic sturgeon as follows:

> In many lower gradient systems, such as Chesapeake Bay, regions of rubble and hard bottom have been buried under meters of sediment due to deforestation, agriculture, and urbanization. In higher-flow systems, access and flow in regions of hard-bottom habitat have been altered in ways detrimental to sturgeon, by dams that support water resource projects such as municipal water supply, irrigation supply, navigation, and hydropower . . . Eutrophication and its common consequence, hypoxia, have disproportionate effects on sturgeons, in comparison to other fauna, because of their limited ability to oxyregulate at low dissolved oxygen levels (Klyashtorin 1976; Secor

> and Gunderson 1998). Hypoxia effects may be particularly important during the first year of life due to increased sensitivity and lessened abilities to escape inundation from hypoxic waters (Secor and Niklitschek 2001). . . . Blocked migration corridors have fragmented segments of historical populations and reduced critical ecological and genetic exchange across habitats, contributing to extinction risk (Anders *et al.* 2001 and 2002, this volume; Jager 2001; Jager *et al.* 2001; Root *et al.*, this volume).

The ASSRT (2007:30) similarly described the threats to Atlantic sturgeon survival posed by adverse modification of its habitat:

> Atlantic sturgeon, like all anadromous fish, are vulnerable to a host of habitat impacts because they use rivers, estuaries, bays, and the ocean at various points of their life. Habitat alterations potentially affecting sturgeon include dam construction and operation, dredging and disposal, and water quality modifications such as changes in levels of DO, water temperature, and contaminants. Loss of habitat and poor water quality have contributed to the decline of Atlantic sturgeon since European settlement.

Habitat destruction and modification has already caused the extinction of several Atlantic sturgeon subpopulations. The Housatonic River subpopulation of Atlantic sturgeon was likely driven extinct by the construction of the Derby Dam in 1870, which blocked over 80% of its habitat. Atlantic sturgeon were reportedly abundant in the Housatonic River before the dam was built, and a large Atlantic sturgeon fishery existed there (ASSRT 2007). Further south, in the Connecticut River, where Atlantic sturgeon no longer spawn, it is suspected that coal tar leachate impaired reproduction. In laboratory tests, only 5% of sturgeon embryos and larvae exposed to Connecticut River coal tar survived. There is evidence that coal tar has caused tumors that prevent spawning in female shortnose sturgeon. There also are high levels of mercury and PCBs in the Connecticut River (ASSRT 2007). Finally, the Atlantic sturgeon population in the St. Mary's River likely became extinct due to reduced DO levels in its nursery habitat during the summer. The reduced DO was caused by eutrophication from non-point source pollution (ASSRT 2007).

1. Dams and Turbines

Dams can significantly impair anadromous fish populations by blocking access to spawning and foraging habitat, changing water flow and temperature, and physically injuring and killing fish as they migrate (ASSRT 2007). Dams have cut off access to large portions of Atlantic sturgeon habitat in rivers like the Cape Fear, Santee-Cooper, and Merrimack (ASSRT 2007).

Atlantic sturgeon do not frequently use fish passage devices, and fish lifts are not designed for them. Only four Atlantic sturgeon have ever been documented using a fish lift (ASSRT 2007). Damming rivers used by Atlantic sturgeon thus often results in loss of access to significant portions of their spawning and foraging habitat. Dams have caused Atlantic sturgeon subpopulations to lose more than 60% of their spawning and foraging habitat in the Cape Fear, St. Johns, and Santee-Cooper rivers, close to 60% of their habitat in the Merrimack River, and approximately 20% of their habitat in the Penobscot and Roanoke rivers (ASSRT 2007).

Entrainment in turbines also causes injury and mortality to eggs, larvae, and juvenile and adult fish as they drift or migrate up- and down-stream. Turbines can slash migrating fish, harming or killing them, and additional injuries and deaths occur from changing pressures (ASSRT 2007). Some turbines have lethal strike probabilities of 40 –80% (ASSRT 2007). Turbines are used with hydropower dams, and also with tidal power plants. There are two tidal power plants in operation in Atlantic sturgeon habitat and many more have been proposed (ASSRT 2007).

Dams can cause daily water flow and temperature to vary substantially, especially when associated with hydroelectric facilities that respond to daily changes in electricity use. Altered water flow and temperature negatively affect water quality and Atlantic sturgeon habitat, decreasing the suitability of habitat for spawning and the survival of larvae and young juveniles (Secor *et al.* 2002). Effects can include acceleration of eutrophication, change in DO levels, artificial destratification, decreased water levels, and changes in sediment loads and nutrient cycling. Dam maintenance requires dredging that deposits silt and other fine river sediments in spawning habitats, removing access to hard substrate necessary for Atlantic sturgeon egg adhesion (ASSRT 2007).

2. Dredging and Blasting

One of the greatest threats to Atlantic sturgeon habitat is dredging and blasting operations in riverine, coastal, and offshore areas. These operations are conducted to support commercial shipping and recreational boating, construction, and mining. Harmful environmental impacts from dredging include direct removal/burial of organisms; turbidity/siltation effects; contaminant resuspension; noise/disturbance; alterations to hydrodynamic regime and physical habitat and actual loss of riparian habitat (ASSRT 2007). Specific impacts to important habitat features for the Atlantic sturgeon include disturbance of benthic fauna, elimination of deep holes, and alteration of substrates (ASSRT 2007). The ASSRT (2007) described recent research finding that Atlantic and lake sturgeon were substrate dependent and avoided spoiled dumping grounds, as well as other research documenting a three to seven-fold reduction in Atlantic sturgeon presence after dredging operations began, indicating that sturgeon avoid these areas during operations.

According to the ASSRT (2007), indirect harm to Atlantic sturgeon resulting from dredging include destruction of benthic feeding areas, disruption of spawning migrations, and deposition of re-suspending sediments in spawning habitat. Dredging operations also directly harm sturgeon by lethally entraining them in dredge drag-arms and impeller pumps. The ASSRT (2007) calculated a minimum take of 0.6 Atlantic sturgeon per year from hopper dredges only, and noted that this may be an underestimate for this technology because observers were only present during time periods critical to already-listed species and thus missed some critical periods for Atlantic sturgeon, and because observers were not present at all on some rivers with Atlantic sturgeon subpopulations. According to the ASSRT (2007), Atlantic sturgeon have also been taken in both hydraulic dredging and bucket and barge operations.

State governments and NMFS impose seasonal work restrictions to protect shortnose sturgeon, already listed under the ESA, but such restrictions often fail to protect Atlantic sturgeon. Shortnose sturgeon are not present in all areas populated by Atlantic sturgeon, and their spawning seasons do not always overlap.

3. Water Quality

Adverse water quality conditions have resulted in, and will continue to result in, the loss and modification of Atlantic sturgeon habitat. Water quality threats to the Atlantic sturgeon include hypoxia (low oxygen), including as a result of high nutrient loadings; toxic and/or bioaccumulative pollutants, including metals and organic chemicals; excessive runoff of silt and soil; and harmful changes to water temperature and flow (ASSRT 2007). These water quality threats are the result of activities in both riparian zones and in watersheds as a whole, including nutrient runoff and erosion from residential and industrial development; discharges of toxic pollutants and changes to water temperature and flow as a result of industrial activities; and erosion, runoff of nutrients and agricultural chemicals, and changes to water flow as a result of agricultural and forestry activities (ASSRT 2007). Poor water quality alone can cause the extinction of entire subpopulations of Atlantic sturgeon -- the Atlantic sturgeon subpopulation in the St. Mary’s River, for example, is believed to have been extirpated by reduced summer dissolved oxygen (DO) levels resulting from eutrophication (ASSRT 2007).

Hypoxic water quality conditions pose a particular risk to Atlantic sturgeon. The species requires higher levels of dissolved oxygen compared to other fish species (ASSRT 2007). Moreover, hypoxic water quality conditions in Atlantic sturgeon habitat have generally increased in spatial extent and frequency over the last century, and this trend is accelerating (Boesch *et al.* 2007; Howarth *et al.* 2006; Kemp *et al.* 2005). Secor (1995, as cited in ASSRT 2007) noted a historical correlation between low sturgeon abundances and an increase in hypoxic conditions. Simulations of lower oxygen levels and/or higher water temperatures in water bodies such as Chesapeake Bay showed that these factors have a dramatic effect on the availability of Atlantic sturgeon habitat (ASSRT 2007).

Relative to other fish species, Atlantic sturgeon also likely have increased susceptibility to toxic chemicals and metals, as a result of their benthic foraging behavior and long life spans (ASSRT 2007). The substrate of certain Atlantic sturgeon habitat, particularly habitat near urbanized areas or large industrial discharges, is contaminated with dioxins, polychlorinated aromatic hydrocarbons (PAHs), organophosphate and organochlorine pesticides, polychlorinated biphenyls (PCBs), and other chlorinated hydrocarbon compounds, as well as toxic metals, such as lead, mercury and arsenic. Atlantic sturgeon are exposed to such contaminants via diet, water, and dermal contact. The species' longevity makes bioaccumulation of chlorinated hydrocarbons and heavy metals a particular concern.

Effects of chlorinated hydrocarbons and/or metals on fish include acute lesions, growth retardation, malformations, reproductive impairment, reduced egg and larval survival, and behavioral (including homing) impacts (ASSRT 2007). Exposure to heavy metals specifically can cause increased mortality in fish species, and chronic toxicity can also lead to reproductive failure, changes to physiology, and increased vulnerability to predation and infection (ASSRT 2007). Heavy metals have affected fish species by reducing their reproductive success by as much as a factor of three, and by causing oxidative stress, brain lesions, altered behavior, and vertebrae fragility (ASSRT 2007).

While studies of the effects of contaminants on Atlantic sturgeon specifically are limited, according to the ASSRT (2007), one study suggested that poor water quality contributed to deformities and ulcerations in Atlantic sturgeon. The ASSRT (2007) also identified studies relating to contaminants in other sturgeon species, including high levels of such contaminants as cadmium, copper, dioxin, mercury, DDE, PCDD/Fs, and PCBs on other sturgeon, and adverse effects such as larval defects, growth abnormalities, and potential for inhibited reproductive capacity. The ASSRT (2007) also cited a study finding that Atlantic sturgeon are more sensitive to various contaminants than three species commonly used for toxicity testing and 12 other species of threatened and endangered fish.

The generally poor quality of benthic habitat in the Northeast is also of concern. The U.S. Environmental Protection Agency ("EPA") classified the benthic index for the coastal waters of the Northeast Coast region as poor in 2008, with 27% of the coastal area rated poor for benthic condition (EPA 2008).

4. Climate Change

According to NMFS:

> Since the 1970s, there has been a historically significant change in climate (Greene *et al.* 2008). Climate warming has resulted in increased precipitation, river discharge, and glacial and sea-ice melting (Greene *et al.* 2008).

Atlantic Salmon GOM DPS Rule at 29356. The Intergovernmental Panel on Climate Change ("IPCC") has also stated that global warming caused by humans is already impacting the habitats and biology of species worldwide. Such effects are occurring faster than scientists had originally predicted (Boesch *et. al.* 2007).

As early as 2001, the IPCC (2001:670 (emphasis added)) noted that "[d]etailed analyses of fish physiological response to water temperature have shown that the potential impact of climate change on freshwater and marine fish is large. . . . High sensitivity to water temperature of fish larval and juvenile stages, combined with the higher susceptibility of headwaters and smaller rivers to air temperature rise, implies important effects of climate change on cold and temperate anadromous species such as . . . **sturgeon (Atlantic** . .)". Most recently, the IPCC (2007:275 (emphasis added)) stated that they have a high level of confidence that "[r]egional changes in the distribution and productivity of particular fish species are expected due to continued warming and local extinctions will occur at the edges of ranges, particularly in freshwater and diadromous species (e.g., salmon, **sturgeon**)."

Global warming is harming Atlantic sturgeon habitat by the following mechanisms. First, global warming increases the occurrence of and/or severity of hypoxic conditions in estuaries, bays, and rivers (Boesch *et al.* 2007). Benthic feeders such as Atlantic sturgeon are more vulnerable to hypoxic conditions than many other fish because they need to feed along the bottom stratum of rivers and estuaries and cannot escape to higher strata when lower strata are hypoxic or anoxic (Boesch *et al.* 2007). The capacity of water to absorb oxygen decreases as it warms; in the Chesapeake Bay, for example, the capacity to dissolve oxygen decreases by about 1.1 percent with each degree Fahrenheit that the water warms (EPA, ND). Global warming is also causing increased precipitation in many estuary systems on the Atlantic coast (Kerr, *et al.* 2009). This results, in turn, in greater discharges of nutrient pollution into rivers and estuaries, leading to increased eutrophication and hypoxic conditions (Howarth *et al.* 2006). These effects are accelerating in recent years and are expected to continue to accelerate (Howarth *et al.* 2006). In the Northeast United States, annual precipitation is expected to increase by 10 percent (Kerr *et al.* 2009), winter precipitation by 10-15 percent (Hayhoe *et al.* 2007, with higher increases in certain areas like Maryland (Center for Integrative Environmental Research ("CIER") 2008). An increase in the number of heavy precipitation events is also predicted (Kerr *et al.* 2009).

Second, higher water temperatures also affect Atlantic sturgeon by raising their metabolic rates and oxygen requirements and by disrupting their ability to osmoregulate (adjust to varying salinities as they migrate, through intake and excretion of ions) (EPA ND; Sardella 2008). Atlantic sturgeon have temperature thresholds above which they cannot thrive or even survive, with past research demonstrating that respiration and survival rates of juvenile Atlantic sturgeon decrease with exposure to hypoxia and high temperatures (Zeigeweid 2008). Because of the influence of temperature as a reproductive cue, increased temperatures are also likely to substantially alter reproductive timing and possibly reproductive success of many fish species (Kerr *et al.* 2009).

Third, global warming causes sea levels to rise, and rising sea levels and changes in salinity negatively impact Atlantic sturgeon survival. Changes in salinity have been shown to affect sturgeon temperature thresholds and their ability to osmoregulate.

According to (Sardella *et al.* 2008), the combined stress of rising ambient temperatures and changing salinities, as is expected to occur with global warming, has a greater impact on sturgeon than either stressor alone. Sardella *et al.* (2008:482), who researched changing salinity and temperature effects on green sturgeon, conclude that:

> The typical range of salinities and temperatures that sturgeon encounter are likely to expand as a result of global climate change . . . . the main deleterious effect of climate change will be a shift in the dominant precipitation type from snow to rain at higher altitudes, resulting in less water storage within the snow pack that maintains the system. Such a shift is likely to result in a larger and less predictable salinity gradient within the estuary, confounding the direct effects of warmer temperature . . . Salinity and temperature combinations that sturgeon are not able to acclimatize to will lead to elevated physiological stress. For example, in this study juvenile sturgeon that were of the age/size class typically found in FW were exposed to higher salinities, and as a result, had a shorter range normal physiological function as temperature was increased. Such physiological stresses resulting from changing abiotic conditions may subsequently reduce fitness and/or force relocation to suboptimal regions within the system, both of which may negatively affect population dynamics and distribution of an already threatened species.

Similarly, Kerr *et al.* (2009) noted that Atlantic sturgeon could face “large population declines and possible extirpations with moderate increases in temperature” as a result of global warming because, while it has a wide distribution, the Atlantic sturgeon:

> is considered a cool-water species due to its sensitivity to warmer temperatures. Existence in more southern latitudes is made possible by thermal refuges in deeper, colder portions of estuaries. However, … increases in temperature due to warming by as little as 1° C can lead to significant reductions in suitable habitat . . . . Furthermore, increases in temperature are likely to be accompanied by decreases in dissolved oxygen and increases in salinity in deeper water, which may lead to additional reductions in suitable habitat.

Other adverse impacts of climate change include (1) as a result of rising sea levels, the implementation of flood mitigation measures, such as dikes, that will interfere with Atlantic sturgeon migration and impair its habitat (Gephard, ND); and (2) increased prevalence of certain marine diseases (Kerr *et al.* 2009).

The ability of Atlantic sturgeon to adapt to climate change depends on genetic and geographic diversity, as maximum gene variation increases the odds that genes will carry traits amenable to climate change adaptation (Gephard, ND). Moreover, the species’ ability to withstand the stresses that will be brought upon by climate change will depend on its resilience and relative vitality. Since many Atlantic sturgeon subpopulations are disappearing or extremely depleted, climate change is a threat to the species as a whole.

5. Threats to Specific Rivers and Estuaries Affecting Atlantic Sturgeon

Kennebec River and Estuary

According to the ASSRT (2007), Kennebec River sturgeon suffer the second highest number of mortalities from dredging, second only to that of Delaware River sturgeon. The Army Corps of Engineers ("ACOE") routinely dredges the lower part of the river, and Bath Iron Works conducts maintenance dredging. Most of the reported mortalities have been shortnose sturgeon, with some Atlantic sturgeon mortality. State and Federal agencies restricted dredging to November through April in an attempt to protect shortnose sturgeon. However, Atlantic sturgeon are likely present year-round (ASSRT 2007).

According to the ASSRT (2007), head-of-tide to mid-estuary regions of the Kennebec and Androscoggin rivers suffered DO levels of zero ppm during summer months in the late 1960s and early 1970s, causing frequent fish kills. Although DO levels have improved since that time, there are multiple other water quality problems impairing the population's ability to recover. Dioxin was found in fish samples from these rivers as recently as 2004, with the Androscoggin holding the record for the highest levels of dioxin in fish the state of Maine. A shortnose sturgeon killed by dredging in the Kennebec River in 2003 had total toxicity equivalent concentrations above adverse effect levels for polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), PCBs, dichlorodiphenyldichloroethylene (DDE), aluminum, cadmium, and copper. As late as 1997, mercury levels in the Kennebec tested at levels exceeding those reported in the literature as harmful to wildlife, and in 1995, PCB levels in Kennebec River bass and bluefish were higher than EPA's screening value. There are still fish consumption advisories in both the Androscoggin and Kennebec rivers (ASSRT 2007).

NFMS has concluded that climate change and warming has caused salinity and thermal changes specifically in the range of the Gulf of Maine DPS of the Atlantic Salmon, which includes the Kennebec, as well as the Penobscot, which is discussed below. The agency also concluded that studies indicate that such "small thermal changes may substantially alter reproductive performance, smolt development, species distribution limits, and community structure of fish populations." *See* Atlantic Salmon GOM DPS Rule at 29377.

Penobscot River

In the Penobscot River, dissolved oxygen levels reached 0 ppm at the freshwater/saltwater interface during summer months in the late 1960s. This is an important area for subadult Atlantic sturgeon. Although DO levels have improved enough for aquatic life to persist, the ASSRT (2007) reported that the substrate remains severely degraded, which has reduced the diversity of the benthic fauna. The mid-estuary and freshwater tidal zones appear to be affected by wood chip debris, and there is a coal tar deposit in the tidal section of the river in Bangor. Since coal tar deposits in the Connecticut River have been linked to tumors and reproductive failure, the tar deposit in the Penobscot River may affect recruitment there. Mercury hotspots also remain.

Appropriations to dredge the Penobscot Harbor were approved in 2003 and the ASSRT (2007) noted that 8 additional projects had been proposed for the river at that time. The continued dredging of nursery grounds threatens the recovery of the Atlantic sturgeon subpopulation (ASSRT 2007). The Veazie Dam blocks 29 kilometers (km) of historically accessible habitat and the Treats Falls Bangor Dam impedes migration during the summer. These dams reduce available spawning habitat for the surviving subpopulation, affecting recruitment. The Penobscot Accord, signed in June 2004, authorizes the Penobscot River Restoration Trust ("Penobscot Trust") to buy the Veazie, Great Works and Howland dams and decommission and/or remove the Veazie Dam, decommission the Great Works Dam, and install fish passages on or remove the Howland Dam. However, these options have not been exercised and may not be unless money is found to fund the project (ASSRT 2007). To date, to the best of Petitioner's knowledge, the Penobscot Trust had not raised sufficient funds to complete this project.

Merrimack River

The Merrimack River subpopulation is extinct, but the river currently serves as foraging and nursery habitat for the Penobscot and Kennebec subpopulations. However, 58% of its habitat is inaccessible due to the Essex Dam in Lawrence, Massachusetts (ASSRT 2007).

According to the ASSRT (2007), an ACOE study in 2003 found high levels of point and non-point sources of pollution in the lower basin, as well as reduced DO and impaired pH. In 2005, there were two fish consumption advisories based on mercury, and in 2007 the Merrimack River watershed in southeastern New Hampshire was identified as a mercury "hot-spot." The Merrimack River was also identified in the 1990's as contaminated with lead, cadmium, chromium, copper, chlordane, DDT, dieldrin, and PCBs (ASSRT 2007).

In addition, climate change will impact Merrimack River habitat. In 1997, EPA projected that Massachusetts winter and spring temperatures will increase by 4° F by 2100, while summer and fall temperatures will increase by an additional 5° F (EPA 1997a) EPA also projected that precipitation in Massachusetts will increase by 15% in the fall, 20-60% in winter, and 10% in spring and summer (EPA 1997b). More recent studies project that temperatures in the Northeast United States will increase by 5° F to 12° F in the winter and 3° F to 14° F warmer in summer (Frumhoff *et. al.* 2007). Warmer temperatures and increased precipitation generally lead to increased occurrence and/or severity of eutrophication and hypoxic conditions (Boesch *et al.* 2007).

Taunton and Connecticut Rivers

While the spawning subpopulations of these rivers are extinct, the rivers are still used as habitat by other Atlantic sturgeon subpopulations. In the Taunton River, Atlantic sturgeon are restricted to the lower 70 km of the river as a result of the Town River Pond Dam cutting off 11% of the river. The historic nursery habitat is still available, but it is most likely unusable due to low DO (< 5 mg/L) and high nutrient levels (ASSRT 2007). In 1970, DO levels were as low as 0.3 mg/L (ASSRT 2007). The ASSRT (2007) reported that, although water quality has slightly improved since that time, very high nutrient levels and very low DO levels still frequently occur. Twenty-three million gallons of treated wastewater are discharged into the Taunton River every day, mostly from a facility in Brockton that was cited multiple times by the EPA in 2003 for discharging water with excessive nutrient content (ASSRT 2007).

In the Connecticut River, the Enfield Dam prevents Atlantic sturgeon from passing the Enfield rapids (ASSRT 2007). In addition, dredging occurs in the lower part of the river every six to seven years to maintain a federal navigation project.

Global warming also affects the habitats of these rivers. Temperatures in Connecticut have been increasing over the last century and are expected to increase an additional 4 or more degrees Fahrenheit in all seasons by 2100 (EPA 1997a; Frumhoff *et. al.* 2007). Precipitation is also predicted to increase by 10-20% (EPA 1997a). As discussed *supra*, increased temperatures and precipitation lead to increased hypoxic conditions, which impairs Atlantic sturgeon's use of the habitat.

Hudson River

The EPA's 2004 National Coastal Condition Report noted particular concern about water quality, sediment, and tissue contaminants in the Hudson River (ASSRT 2007), and the 2008 National Coastal Condition Report rated the NY/NJ region's water quality as poor (EPA 2008). PCBs were detected in Atlantic sturgeon flesh at 6.72 ppm during the 1970's. This is more than three times the FDA limit (2 ppm) for edible portions of fish. PCBs cause fin erosion, epidermal lesions, anemia, immune system disorders, reproductive failure, and mortality in fish. While the PCB levels have declined since the 1970s, fish consumption advisories based on PCB contamination are still in place for fish caught between Troy Dam and Catskill. There also are fish consumption advisories for three species of Hudson River fish in other parts of the river based on mercury, PCB, and cadmium contamination (ASSRT 2007).

Sewage discharge into parts of the Hudson River has been increasing due to population growth in communities discharging into the River, and the decomposition of the sewage has caused hypoxic areas to form in multiple parts of the river (ASSRT 2007). Climate change is likely to exacerbate this by decreasing oxygen levels in the river, including by increasing precipitation, and therefore discharges of nutrients, into the river, resulting in increased occurrence and/or severity of eutrophic conditions (Howarth *et al.* 2006).

The Hudson River subpopulation of Atlantic sturgeon is also threatened by Verdant Power's proposal to build a marine turbine project on the East River, New York. The company tested two slow speed tidal turbines from 2006-2007 and has since installed four more (ASSRT 2007; Ordóñez 2008). The ultimate goal of Verdant Power is to build up to 300 turbines within a one-mile section of the river near Roosevelt Island. The ASSRT (2007) was concerned that potential foraging and nursery habitat of Hudson River Atlantic sturgeon could be adversely affected by this project.

Delaware River

The Delaware River Atlantic sturgeon subpopulation is more affected by dredging operations than any other subpopulation. Dredging has already made one of the subpopulation's two historic spawning habitats unusable. Historically, Atlantic sturgeon spawned near Pea Patch Island and near Pedrickston, New Jersey below Philadelphia. However, hydrodynamic alterations from past dredging operations and water sharing agreements with upstream towns has caused salt water encroachment and made Pea Patch Island unsuitable spawning habitat for periods of time (ASSRT 2007).

According to the ASSRT (2007), the largest annual dredging-related take of sturgeon occurs in the Delaware as a result of a multi-state ACOE project. The navigation channel is dredged each year from the mouth of Delaware Bay to just north of Trenton, and an average of 6 Atlantic sturgeon per year are reported killed in the process. The Delaware River Fish and Wildlife Management Cooperative has imposed "no work" windows to protect diadromous species (ASSRT 2007). However, the recurrent and frequent dredging of significant spawning and nursery grounds continues to adversely impact sturgeon by degrading habitat and spreading contaminants (ASSRT 2007).

Crown Landing, LLC has proposed construction and operation of a Liquefied Natural Gas (LNG) import terminal on the Delaware River near Logan, New Jersey. This proposal was approved by the FERC in 2006 and has the potential to seriously impact the Delaware River Atlantic sturgeon population. Construction of the LNG terminal will require hydraulic dredging of 1.24 million cubic meters ("m3") in the first year followed by maintenance dredging of 67-97,000 m3/year. Dredging will occur from August through December in a location believed to be historical spawning habitat, and possibly current spawning habitat, for Atlantic sturgeon. The ASSRT (2007:45) considers this dredging project to "threaten the viability of this subpopulation."

The Delaware River subpopulation is also threatened by exceptionally poor water quality. Chemicals and untreated sewage have been discharged into the Delaware River for at least 200 years, and pollution from oil and dyes specifically appears to have contributed to the decline of the Atlantic sturgeon subpopulation (ASSRT 2007). In giving the Northeast region an overall grade of F for water quality and coastal habitat, the EPA's National Coastal Condition Report (2004) noted particular concern about water quality and tissue contaminants in the Delaware River. EPA's 2008 update rated the water quality in the Delaware River as poor because of high nitrogen and phosphorous levels; several tributaries of Delaware Bay were also given a poor rating (EPA 2008). The

Delaware River also has high levels of PCBs, dioxins, mercury, and chlorinated pesticides in its sediments and is subject to consumption advisories for numerous fish. In 2002, elevated levels of cadmium, copper, DDE, PCDD/Fs, and PCBs were found in the gonad and liver tissue from two shortnose sturgeon from the Delaware River. Part of the Roebling-Trenton stretch of the river is still a EPA Superfund site contaminated with remnant pollutants from the Roebling Steel plant.

Finally, climate scientists predicts that the impacts of global warming will be particularly significant in the Northeast and mid-Atlantic regions, and encompassing the Delaware. As discussed *supra*, among other impacts, global warming will exacerbate hypoxic conditions by increasing precipitation and the flow of nutrients into the waterway (Howarth *et al.* 2006).

Chesapeake Bay (James and York Rivers)

According to the ASSRT (2007), the James River's habitat was severely impacted by dredging in the 1800s when granite outcroppings believed to be ideal Atlantic sturgeon spawning habitat were removed to improve ship navigation. The river is still dredged almost every year to allow commercial ships to reach the Richmond terminal. The EPA has rated benthic condition in Chesapeake Bay as poor (EPA 2008). The ASSRT (2007) noted that six new dredging permits had been issued over the past decade and another 24 maintenance projects had been approved as of that time. These additional dredging projects may further impair spawning.

Hypoxia is a significant concern for sturgeon in both the James and York rivers and in the Bay as a whole. More than 50% of benthic habitat in the Chesapeake Bay watershed experiences hypoxia and some benthic areas are anoxic (Preston 2004). Bottom-water hypoxia and anoxia in the main stem of the Bay is a fairly recent occurrence, with significant increases in severity and spatial extent since the 1950s (Kemp *et al.* 2005). The Bay experienced "record-sized hypoxic zones" in 2003 and 2005 (Boesch *et al.* 2007:2). Kemp *et al.* (2005:9) stated that:

> the Bay has become less able to assimilate N inputs without developing hypoxia, a change that may have arisen from the degradation of key ecological processes sensitive to eutrophication effects. Potential mechanisms include (1) loss of benthic plant biomass due to increased turbidity and loss of oyster biomass, both of which tend to retain nutrients and organic matter in shallow waters; (2) increased efficiency of N and P recycling with marked decreases in denitrification and P precipitation in response to recent severe and persistent hypoxia.

The ASSRT (2007) also noted low DO trends within the York River, and the EPA's National Coastal Condition Report III noted continued hypoxia in the deeper channels of the Bay (EPA 2008).

EPA, in its National Coastal Condition Report (2004), gave Chesapeake Bay a score of F for water quality, sediment, benthos, and fish tissue, and in its 2008 update rated the northern and western tributaries of the Bay as poor (EPA 2008). The extremely poor environmental conditions have severely impacted the viability of the Atlantic sturgeon subpopulations. "[W]ithin the Chesapeake Bay, a combination of low DO, water temperature, and salinity restricts available Atlantic sturgeon habitat to 0-35% of the Bay's modeled surface area during the summer" (ASSRT 2007:34). As the ASSRT (2007:47) explained, sturgeon require higher levels of DO than other species and

> juvenile Atlantic sturgeon [are] less tolerant of summer-time hypoxia than juveniles of other estuarine species. Over the last 50 years, high nutrient inputs have contributed to [algal blooms which cause] high spatial and temporal incidence of summer-time hypoxia and anoxia in bottom waters. . . . The Bay is especially vulnerable to the effects of nutrients due to its large surface area, volume ratio, relatively low exchange rates, and strong vertical stratification during spring and summer months. . . . [T]he system [is] squeezed or stressed in the summer months.

Another effect of poor water quality has been the limited availability of clean, hard substrate to which Atlantic sturgeon eggs can adhere. Availability of suitable spawning habitat is already severely limited as a result of sediment loadings from prior activities, such as silviculture (ASSRT 2007).

Climate change is "an emerging stress for the estuary" (Preston 2004:126). Water temperatures within Chesapeake Bay during the 20th century were 2-3° C warmer than over the past millennium, and increased 0.8-1.1° C just between 1949 and 2002 with "unambiguous and prominent estuarine warming over at least the past two decades" (Preston 2004:134). Observed average annual water temperatures in the Patuxent River have increased 0.22° C per decade for the period 1938-2006 and in the two most recent decades by ~0.5° C in the winter and spring (Kerr *et al.* 2009). According to Boesch *et al.* (2007), climate change has already exacerbated hypoxic conditions in parts of the Chesapeake Bay. For example, the "record-sized hypoxic zones" in 2003 and 2005 were caused or exacerbated by climate change-induced high river inflows, warm temperatures, and calm winds (Boesch *et al.* 2007:2).

Models predict air temperature will be 3–4.5° C warmer by the end of the present century, with potential summer increases of 6.5º C in combination with more extremely warm days and more modest winds. Warmer air and water temperatures are likely to further increase the severity of hypoxia and extend hypoxic regions into shallower areas of the Bay because higher temperatures reduce the amount of oxygen that can be dissolved in the water, enhance stratification, and increase rates of production, decomposition, and nutrient cycling (Boesch *et al.* 2007; Preston 2004). Modeling by Niklitschek *et al.* (2005) predicted that that increasing water temperature by just 1° C bay-wide would reduce suitable Atlantic sturgeon habitat by 65%.

Recent climate change models also predict increased fresh water flows into Chesapeake Bay during winters and springs, increasing hypoxia by reducing the salinity of the water and the oxygen exchange between warmer surface waters and cooler deep waters (CIER 2008). Precipitation is expected to increase 20 percent in Maryland by the end of the century (CIER 2008). Higher precipitation and run-off levels are expected to increase nitrogen flux within the Susquehanna River, which is the major source of nitrogen discharge into Chesapeake Bay, by as much as 17 percent by 2030 (Howarth 2006).

Increasing sea levels resulting from global warming will likely further increase the bay's hypoxia problem. Chesapeake Bay water levels are rising at 3-4 mm per year, twice the rate of the global average of sea level rise (CIER 2008; EPA ND). The EPA estimates that sea level in the Chesapeake Bay area is likely to rise 8 inches by 2025, 13 inches by 2050, and 27 inches by 2100, from the 1990 level (EPA ND). The federal agency noted that after averaging approximately 36 inches of sea level rise per 1,000 years for the last 5,000 years, the Bay could see that much of an increase in just the next 100 years, and there was a 5 percent chance, based on recent computer models, that the sea level will rise 44 inches by 2100 (EPA ND). Boesch *et al.* (2007) note that the projected local sea level would increase the Bay's volume by 9 percent unless the Bay also fills in with sediment at an increased rate. Sea level rise affects hypoxic conditions by increasing stratification via changes in the ratio of salt to fresh water (Boesch *et al.* 2007). Tidal marshes around Chesapeake Bay that currently serve as nutrient barriers are also being lost as a result of rising sea levels, leading to increased nutrient discharges that further contribute to the problem (Kemp *et al*. 2005).

Finally, warming temperatures can affect recruitment and the distribution of pathogens (Preston 2004; Kerr 2009). This may make Atlantic sturgeon in the bay more vulnerable to disease, particularly in conjunction with the additional stress brought on by suboptimal environmental conditions (Preston 2004).

Cumulatively, the adverse impacts on Atlantic sturgeon in Chesapeake Bay from climate change are likely to be significant. The University of Maryland's CIER (2008) predicts losses of Atlantic sturgeon as water temperatures skirt the upper limits of their habitable temperature range. Boesch *et al.* (2007:10) warns that "[p]rolonged shifts in climate and its variability, or in the biota inhabiting the bay, may have unprecedented effects that drive the ecosystem to a new state." Kemp *et al.* (2005:17) warn that "sturgeons, extirpated nearly a century ago by fishing and habitat loss, probably can no longer reproduce or rear young in the eutrophic Bay due to lack of summer habitat with O_2 and temperature levels needed for growth and survival."

Roanoke River

It is likely that Atlantic sturgeon historically ascended Roanoke Rapids to spawn, but the Roanoke Rapids Dam has blocked their access since 1955. There are two additional dams above Roanoke Rapids, the Gaston and Kerr dams. Assuming that spawning historically occurred above the fall line, Atlantic sturgeon currently are blocked from 18% of their historic habitat in the Roanoke River. In addition to making habitat inaccessible, these dams affect water flow, water temperature, and oxygen levels in the river. Lower water temperatures due to hypolimnetic discharge from Kerr Dam have likely caused Atlantic sturgeon spawning peaks to temporally shift (ASSRT 2007).

Dominion Generation has applied for a "major new hydropower license" on the Roanoke River; as a result, a fishway prescription for the Roanoke Rapids and Gaston dams was filed in 2006. However, the ASSRT (2007:49) noted that "Atlantic sturgeon were not a management objective in this prescription due to their low population size and lack of safe and effective downstream passage mechanisms for post-spawn adults."

There are two fish consumption advisories for the Roanoke River based on dioxin, as well as a general advisory for mercury. Fish kills occur during summer months due to large hypoxic plumes that result from the coincidence of high water flow, warmer ambient temperatures, and an influx of swamp water with low DO. This impairs potential Atlantic sturgeon nursery habitat in the lower part of the river (ASSRT 2007).

Pamlico Sound/Neuse River

The ACOE conducts extensive annual dredging for boating access in the Atlantic Intercoastal Waterway through all major inlets and tributaries of Pamlico Sound. Dredging is currently restricted in some of the waters during the spring spawning season to protect diadromous fish (ASSRT 2007).

The ASSRT (2007:50) warned that "[w]ater quality in the Pamlico system, especially in the lower Neuse River, is of serious concern. The lower Neuse River has been the site of many fish kills and much concern in recent years because of outbreaks of a toxic dinoflagellate, Pfiesteria piscicida . . . The entire basin has been designated as nutrient-sensitive . . . Both the Neuse and Pamlico portions of the estuary have been subject to seasonal episodes of anoxia that significantly affect the quality of Atlantic sturgeon nursery habitat." The number of concentrated animal feeding operations ("CAFOs") have increased significantly in the coastal portion of the basin over the past decade, which has resulted in an increase in the amount of nitrogenous waste products discharged into the sound. Fish consumption advisories for carp, catfish, and largemouth due to mercury and PCB contamination have been instituted (ASSRT 2007). In addition, the Milburnie Dam has impaired water flow in the Neuse River. While the flow from the dam has been temporarily increased to try to restore more natural conditions, this regime has not been permanently established and could be changed in the future (ASSRT 2007).

Cape Fear River

According to the ASSRT (2007), dams impede access to 64% of Atlantic sturgeon habitat in the Cape Fear River. Sturgeon are blocked by a lock and dam at Riegelwood, NC, the first of four locks and dams below the fall line; there are an additional two dams above the fall line. Atlantic sturgeon spawning habitat in the Cape Fear River is completely unusable in years when the salt water interface reaches the Riegelwood lock and dam.

Atlantic sturgeon are prevented from spawning in those years, or spawn in tributaries (ASSRT 2007).

Water quality in the Cape Fear River is also impaired due to industrial pollution and CAFOs. CAFOs are particularly dense in the Cape Fear River drainage within North Carolina. Nitrogen pollution causes DO levels in the river to regularly fall below the 5 mg/L state standard and fish kills have been observed in recent years. Fish advisories also exist for two species due to mercury contamination (ASSRT 2007).

Extensive dredging occurs on the lower Cape Fear River, as well as the Brunswick River and at the port facilities of the U.S. Army's Sunny Point Military Ocean Terminal and Port of Wilmington (ASSRT 2007). The ASSRT (2007) noted that Atlantic sturgeon have been killed by hydraulic pipeline and bucket-and-barge operations in the river.

Winyah Bay/Great Pee Dee River

Water quality in Winyah Bay has deteriorated due to the presence of paper mills, steel mills, and other industries in the Sampit River arm of the bay. Sediment samples contain high levels of dioxins and other toxic contaminants. There are fish consumption advisories for three fish species in the system due to mercury contamination (ASSRT 2007).

Dredging in Winyah Bay and its shipping channel is restricted in the summer to protect sea turtles. However, Winyah Bay is likely inhabited year-round by age 1-4 juvenile Atlantic sturgeon that are not protected at other times of year (ASSRT 2007). In the Great Pee Dee River, Atlantic sturgeon spawning habitat is partially blocked by the Blewett Falls Dam (ASSRT 2007).

Santee and Cooper Rivers

Sixty-two percent (62%) of the Atlantic sturgeon habitat in the Santee and Cooper rivers is inaccessible due to dams (ASSRT 2007). Water flow is also disrupted, with a weekly average flow of 4,500 cubic feet per second ("cfs") diverted through the Jefferies Hydroelectric Station on the Cooper River. The Santee Dam restricts water flow so significantly that flows above 600 cfs only occur through occasional unregulated spills (ASSRT 2007).

The Santee-Cooper Project diverted the Santee River into the Cooper River and resulted in increased shoaling within Charleston Harbor. To reduce the need for frequent harbor dredging, a re-diversion canal, including a new hydroelectric dam, the St. Stephen Hydropower Project, was constructed. The dam includes a fish lift but the lift was not designed to attract or pass Atlantic sturgeon and they do not use it (ASSRT 2007).

The Cooper River is dredged without any seasonal restrictions. Dredging offshore of Charleston Harbor is stopped during the summer months to protect sea turtles, but subadult Atlantic sturgeon congregate there in the winter and are not protected (ASSRT 2007). Contaminated sediment from past industrial operations and military facilities has led to fish consumption advisories for three species due to mercury contamination (ASSRT 2007).

Savannah River

The New Savannah Bluff Lock and Dam (NSBL&D) at Augusta blocks access to 7% of the Atlantic sturgeon subpopulation's historically available habitat. While the NSBL&D has five vertical spillway gates for fish passage, the ASSRT (2007) could find no documented passage of Atlantic sturgeon.

The lower Savannah River is heavily industrialized and serves as a major port. Atlantic sturgeon nursery/foraging habitat in the lower river has been heavily impacted by water pollution and channelization. The river channel was substantially deepened in 1994, and frequent maintenance dredging continues in Atlantic sturgeon nursery habitat. The only seasonal no-work window in place is from March 16th – May 31st for the protection of striped bass (ASSRT 2007). Channelization may also be causing reduced DO levels and upstream movement of the salt wedge (ASSRT 2007), and mercury contamination is prevalent, with five species subject to advisories (ASSRT 2007). Similar to the Altamaha River, *see* discussion *infra*, Atlantic sturgeon habitat in the Savannah River will be negatively impacted by global warming.

Georgia Ports Authority has proposed to expand their port facility on the Savannah River, which will require deepening of the Savannah Navigation Channel by another six feet. According to the ASSRT (2007:55), hydrodynamic and water quality models indicate that this "may negatively alter overall water quality (*e.g.*, salinity and DO), creating inhospitable foraging/resting habitat in the lower Savannah River for sturgeon." The ASSRT (2007) also noted that the proposed expansion of the Elba Island LNG Terminal, near Savannah, will require pile driving, dredging, and construction barge activities.

Ogeechee River

According to the ASSRT (2007), Atlantic sturgeon nursery habitat in the Ogeechee River downstream of the Jordan Mill Pond Dam is likely impaired by reduced water flow during hot, dry summers, resulting in increased water temperature and hypoxia. DO levels in the Ogeechee River have dropped to approximately 4 mg/L on an annual basis in recent years (ASSRT 2007).

Altamaha River

The drainage basin of the Altamaha River is dominated by the silviculture and agriculture, with two paper mills and over two dozen municipalities or other industries discharging into the river. The ASSRT (2007) determined that nitrogen and phosphorus pollution in the river are increasing, and as a result eutrophication and loss of thermal refugia are concerns. Increased temperatures associated with global warming will likely increase such habitat harm. Ziegeweid *et al.* (2008:299), in his research on thermal thresholds for shortnose sturgeon, found that "summer temperatures in southeastern rivers may be lethal to YOY shortnose sturgeon if suitable thermal refuge cannot be found." (Ziegeweid *et al.* 2008). Past research indicates that juvenile Atlantic sturgeon are similarly vulnerable.

Sturgeon habitat in the Altamaha River is also likely harmed by dredging and thermal pollution associated with the Hatch Nuclear Power Plant, located on the Altamaha River 11 miles northeast of Baxley, GA (ASSRT 2007). Dredging associated with the plant's water intake structures removes approximately 14,000 cubic yards of material from the floor of the Altamaha River every year (ASSRT 2007). The intake structure also takes in 88 cfs of water from the river and discharges 50 to 58 cfs of water at temperatures ranging from 62 degrees Fahrenheit in the winter to 94 degrees Fahrenheit in the summer.

St. John's River

Sixty three percent (63%) of Atlantic sturgeon habitat in the St. Johns River is no longer accessible (ASSRT 2007). The Kirkpatrick Dam now blocks migration to extensive potential spawning habitat upstream (ASSRT 2007). Frequent dredging has reduced submerged aquatic vegetation in Atlantic sturgeon foraging habitat in the river and may also have affected nursery habitat (ASSRT 2007). Water quality is degraded, and in the summer months DO is frequently at low levels (ASSRT 2007).

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

1. Direct Harvest

At one time, Atlantic sturgeon were commercially harvested in every major Atlantic coastal river system. Commercial sturgeon harvests focused on spawning migrations, resulting in the sturgeon being killed before they could reproduce (ASSRT 2007). Such commercial over-harvesting caused a precipitous decline in abundance of Atlantic sturgeon. By 1990, Pennsylvania, the Potomac River Fisheries Commission, the District of Columbia, Virginia, South Carolina, and Florida had all prohibited harvest of Atlantic sturgeon. By 1996, all states but Rhode Island, Connecticut, Delaware, Maryland, and Georgia had closed their Atlantic sturgeon fisheries. In June 1998, the ASMFC amended their Atlantic sturgeon plan to include a complete moratorium on harvest until 20 year classes are established (20-40 years).

While direct harvest is now illegal, the pressures of high domestic demand for caviar and sturgeon flesh, combined with declining sturgeon populations elsewhere in the world, have led to active poaching of Atlantic sturgeon throughout its range in the United States (Secor *et al.* 2002). Stein *et al.* (2004:179) noted that bycatch levels for the period he studied were so high that "sturgeon must have been the subject of some level of targeting." Dr. David Secor reported to the ASMFC Atlantic Sturgeon Management

Board ("ASMB") that a single poaching incident in Virginia in the late 1990's resulted in close to a hundred Atlantic sturgeon mortalities (ASMB 2007). The ASSRT (2007:60) emphasized that:

> [d]espite the fact that the fishery has been closed coastwide since 1995 and in certain states prior to then (NC, 1991; SC, 1985), poaching of Atlantic sturgeon continues and is a potentially significant threat to the species, but the present extent and magnitude of such activity is largely unknown. Instances of documented poaching have occurred since the [1998] Status Review, several of them very recent, indicating that poaching is contributing to Atlantic sturgeon mortality, and should be considered along with bycatch in other legal fisheries as a factor in assessing present threats. Poaching has been documented by law enforcement agencies in Virginia, South Carolina and New York.

2. Bycatch

Despite the closure of Atlantic sturgeon fisheries, Atlantic sturgeon remain susceptible to bycatch mortality from other fisheries in rivers, estuaries, coastal fisheries, and the nation's exclusive economic zone ("EEZ") (Grunwald *et al.* 2008 ASSRT 2007). Atlantic sturgeon, as anadromous species, are particularly vulnerable to bycatch, and such bycatch is difficult to monitor, because they are subject to incidental take in multiple habitats (ASSRT 2007). Moreover, as Stein *et al.* (2004:171) noted, mortality from bycatch is a "particularly acute" problem in Atlantic sturgeon and other long-lived marine species because of late maturation and inconsistent spawning intervals. Similarly, the ASSRT (2007:77) noted that "Atlantic sturgeon are considered to be more sensitive to fishing mortality as they are a long-lived species, have an older age at full maturity, have lower maximum fecundity values, and 50% lifetime egg production occurs later in life than other coastal species with no fishing mortality (Boreman 1997)."

The ASMFC (2007b:5) concluded that "[t]o remain stable or grow, populations of Atlantic sturgeon can sustain only very low anthropogenic sources of mortality (< 4% per year)." Secor *et al.* (2002:8) similarly stated that "[b]ecause sturgeons can only sustain harvest rates of single digit percentages, even low levels of bycatch in other fisheries . . . can result in further decline following closures of directed fisheries."

Information concerning Atlantic sturgeon bycatch can be drawn from a variety of sources, including landing records, tagging and recapture studies, fishing log books, the Maryland reward program, the FWS Coastal Tagging Database, and the NMFS observer program (ASSRT 2007). As the ASSRT (2007:105) points out, most of these sources rely on voluntary reporting rather than independent observers, and are considered to produce underestimates of sturgeon bycatch: "Currently, most states rely on fishers voluntarily reporting bycatch of Atlantic sturgeon. Very few to no Atlantic sturgeon have been documented each year by commercial fishers using this voluntary reporting scheme. In states and programs where observer coverage is present, however, Atlantic sturgeon are landed with some frequency and bycatch mortality ranges from 0 – 51% mortality."

Fisheries surveys used to monitor the abundance of certain different fish stocks and using fishing gear similar to that used in the respective commercial fisheries frequently capture Atlantic sturgeon, indicating that capture in those commercial fisheries is also likely common. For example, the ASMFC (2008) reported that in 2007, 10 Atlantic sturgeon were caught in trawl and gillnet surveys in Rhode Island waters, 30 Atlantic sturgeon were captured in the James River in staked gill net surveys for shad abundance, 5 Atlantic sturgeon were captured in the Albemarle Sound gillnet survey, and 5 Atlantic sturgeon were captured in the American shad drift gill net survey in the Altamaha River.

Stein *et al.* (2004), analyzing data from records collected by onboard observers on fishing trips between 1989 and 2000, estimated that approximately 1,500 Atlantic sturgeon may be killed every year as bycatch. The ASMFC (2007b), using a different modeling approach and data sets (*i.e.*, observer data from the years 2001-2006, and the New England and Mid-Atlantic regions only) estimated annual mortalities of Atlantic sturgeon ranging from 352 to 1,286. The bycatch mortality estimates by Stein, *et al.* (2004) and ASMFC (2007b) do not include the bycatch that occurs in estuaries and rivers, which are not covered by the observer programs. Many juveniles and adults stay in marine foraging areas from fall through spring and then migrate into the estuaries and rivers in the summer seeking thermal refuges (Stein *et al.* 2004). While bycatch decreases in the ocean during the summer relative to fall through spring due to the migration to estuaries and rivers, bycatch likely increases in estuaries and rivers during that time. Bycatch in gill nets in river systems is recognized as a substantial cause of mortality for Atlantic sturgeon (Stein *et al.* 2004). The FWS Tagging Program Data indicates that the highest bycatch of Atlantic sturgeon in non-marine environments occurs in May and June (ASSRT 2007).

Most Atlantic sturgeon bycatch in commercial marine fisheries occurs in the gill net and trawl fisheries (ASSRT 2007). Most Atlantic sturgeon bycatch mortality is attributed to gillnet fisheries, and to the use of sink gill nets specifically (Stein *et al.* 2004; ASMFC 2007b; ASSRT 2007). The high mortality rate for Atlantic sturgeon caught in gill nets appears to result from their dense dermal ossifications catching the net strands, which leads to restricted ventilation (ASSRT 2007). Stein *et al.* (2004) calculated that 84% of recorded captures came from sink gill nets and that such captures increased from 32,000 pounds in 1986 to 150,000 pounds in 2000 while drift gill net captures held steady at approximately 50,000 pounds per year. An Atlantic Coast Sturgeon Tagging Database study conducted from 1992-2003 also found that the majority of bycatch captures (62%) were in anchored gill nets. Sink gill nets had an estimated 22% mortality rate, and drift gill nets had an estimated 10% mortality rate (ASSRT 2007). The NMFS observer program, which observed 433 Atlantic sturgeon captures between 2000–2004, determined that 91% of the captures occurred in fixed gill nets and that these nets had a mortality rate of 30% (ASSRT 2007). Stein *et al.* (2004) concluded that sink gill nets killed approximately 1,000 Atlantic sturgeon per year, and that drift gill nets killed an estimated 385 individuals per year.

Significant bycatch of Atlantic sturgeon occurs in trawl fisheries, in part because of the large scale of these fisheries in the Atlantic sturgeon's marine habitat. Stein *et al.* (2004) estimated approximately 150,000 to 200,000 pounds of Atlantic sturgeon were caught annually in trawl fisheries from 1986-2000 (compared to 32,000-150,000 pounds in gill net fisheries); ASMFC (2007b) estimated approximately 2,167 to 7,210 Atlantic sturgeon were caught annually in trawl fisheries from 2001-2006 (compared to 1,135-2,617 fish in gill net fisheries). In 2007-2008, NMFS observers recorded significantly higher bycatch, more than a 2:1 margin, in trawl fisheries than in gill nets (NMFS 2009). According to Stein *et al.* (2004), Atlantic sturgeon caught in trawl gear was not found to experience significant immediate mortality but post-release injuries and mortality can occur from stress, scale damage, or disease. The ASMFC Stock Assessment estimated a coast-wide value of 5% immediate mortality in trawl fisheries, not counting any post capture mortality (ASSRT 2007). Mortality rate from trawls likely varies by region, with longer trawl duration and water warmer resulting in higher mortality rates in the southern states (ASSRT 2007).

For commercial marine fisheries, Stein *et al.* (2004) found the highest Atlantic sturgeon bycatch rates in Maryland, Virginia, and North Carolina. Although the data showed the highest bycatch rates in these states, the highest number of observed bycatch occurrences occurred in New Jersey and Massachusetts, with 64% of the total observed sturgeon bycatch occurring in New Jersey, Massachusetts, and North Carolina (Stein *et al.* 2004). The FWS Atlantic Coast Sturgeon Tagging Database found that most recaptures occurred off the coast of New Jersey, the mouth and interior of the Chesapeake Bay, and the eastern portion of Albemarle Sound, NC (ASSRT 2007). NMFS observer data from 2000-2006 indicates concentrations of bycatch in Chesapeake Bay, the mouth of Chesapeake Bay, off the Maryland coast, in the northern NY/NJ Bight, off the Rhode Island coast, and in Cape Cod-Gulf of Maine (ASMB 2007; ASMFC 2007b). 2007-2008 NMFS observer data showed the highest bycatch rates off the Virginia and North Carolina coasts, in the vicinity of Albemarle and Pamlico sounds, and the mouths of Chesapeake and Delaware bays (NMFS 2009).

Stein *et al.* (2004:182) concluded that "[w]ithin the marine and freshwater environments, bycatch is a serious problem that affects sturgeon populations." Similarly, the ASMFC (2007b) determined that, based on most estimates of bycatch and recruitment levels, bycatch mortality for the Hudson River subpopulation specifically exceeds levels believed necessary to sustain a stable population, and that the smaller subpopulations in other rivers are likely affected to an even larger degree. The ASSRT (2007:77) concluded that bycatch could be "hav[ing] a substantial impact on the status of Atlantic sturgeon, especially in rivers or estuaries that do not currently support a large subpopulation (< 300 spawning adults per year)."

3. Threats to Specific Rivers and Estuaries Affecting Atlantic Sturgeon

Hudson River

Overharvest has been a major factor in the decline of the Hudson River Atlantic sturgeon subpopulation. When the South Carolina fishery was closed in 1985, the New York and New Jersey fisheries increased their harvests to satisfy market demand. In the Hudson River, the fishery primarily harvested adults during their spawning run, preventing them from reproducing (ASSRT 2007). Landings from direct harvest continued until 1996, averaging 49 metric tons per year. In 1996, when it became clear that the subpopulation was being overfished, New York instituted a harvest moratorium and New Jersey instituted a zero quota (ASSRT 2007).

It has been estimated that bycatch rates must remain below 3-4% to allow the Hudson River subpopulation to remain stable (ASSRT 2007; ASMFC 2007b). The ASMFC (2007b:5) has concluded, however, that "[f]or many likely scenarios of contribution to coastal bycatch and recruitment levels, bycatch mortality for the Hudson River population exceeds those levels believed to lead to a stable or growing population." Sub-adult Atlantic sturgeon (< 1m) are also still caught in the Hudson River as bycatch in the American shad gill net fishery.

Bycatch of Atlantic sturgeon also has been documented in the Taunton River's offshore dogfish, cod, and striped bass fisheries, and in the Connecticut River's commercial shad fishery (ASSRT 2007; ASMFC 2008). At least in part, these sturgeon are likely from the Hudson River spawning subpopulation.

Delaware River

Historically, the Delaware River Atlantic sturgeon subpopulation was the largest in the United States, with an estimated 180,000 spawning females in 1890. Between 1890 and 1900, 75% of the Atlantic sturgeon captured in the U.S. were caught in Delaware Bay, with a peak recorded harvest of 3,350 metric tons in 1888 (Wirgin *et al.* 2007; ASSRT 2007). The fishing camps in New Jersey intercepted spawning runs along the eastern shore, capturing most females before they could reach their spawning grounds. Largely because of this practice, Delaware and New Jersey landings dropped to 6% of peak levels by 1901 (Wirgin *et al.* 2007). Reported landings of Atlantic sturgeon in the Delaware River diminished to zero by 1993, three years before New York instituted a harvest moratorium and five years before the coastwide ASMFC moratorium (ASSRT 2007).

New Jersey reported to the ASMFC that 79 Atlantic sturgeon were caught as bycatch in 2007 (58 in coastal waters and 19 in Delaware Bay), based on an extrapolation from the logbooks of six commercial shad fishermen (ASMFC 2008). This estimate is considered an underestimate (ASMFC 2008). Based on a similar extrapolation from logbooks voluntarily submitted by commercial gill netters (striped bass, American shad and weakfish) to the State of Delaware, it was estimated that the entire fishery caught 386 Atlantic sturgeon as bycatch (ASMFC 2008).

In Delaware Bay, most bycatch is believed to occur in the American shad, striped bass, weakfish, and white perch fixed gill net fisheries between March and May (ASSRT 2007). Although fishermen report that bycatch mortality in Delaware Bay is low, "[m]any fishery managers believe that Atlantic sturgeon bycatch and mortality are vastly underreported along the Atlantic coast (W. Patrick, NMFS, Pers. Comm. 2006)" (ASSRT 2007:64). Bycatch mortality in Delaware River anchored gill nets was reported to be 10 percent (ASSRT 2007). Such levels of bycatch represents a substantial problem for the subpopulation because even small amounts of bycatch can seriously impact subpopulations with fewer than 300 spawning adults, such as the Delaware subpopulation (ASSRT 2007).

Chesapeake Bay (James River)

Poaching is a significant concern for the James River subpopulation of Atlantic sturgeon. In 1998-1999, state and federal law enforcement agents in Virginia arrested commercial fishermen who had killed approximately 95 Atlantic sturgeon from the James and Poquoson rivers; a black market for sturgeon in Virginia is believed to still exist (ASSRT 2007). Given the very small size of this subpopulation, significant high mortality from poaching is a substantial threat to viability. In addition, juvenile and subadult Atlantic sturgeon are routinely taken as bycatch throughout Chesapeake Bay in a variety of fisheries (ASSRT 2007).

Albemarle and Pamlico Sounds

According to the FWS Atlantic Coast Sturgeon Tagging Database, the eastern portion of Albemarle Sound is one of the top four locations in the U.S. for Atlantic sturgeon bycatch (ASSRT 2007). The ASSRT (2007:73-74) warns that "data indicate that underreporting of sturgeon bycatch is occurring at extreme levels in this area." A mortality rate of 12% was observed, with most mortality occurring in the summer (ASSRT 2007).

Bycatch also occurs as a result of research activities. The Albemarle Sound Independent Gill Net Survey, targeting finfish species, captured 842 sturgeon between 1990 and 2005. There were 67 mortalities during this time, averaging more than 4 per year (8% mortality rate) (ASSRT 2007). The Pamlico Sound Independent Gill Net Survey, conducted since 2001, has captured 14 sturgeon with zero immediate mortalities. Post-release mortalities are not studied (ASSRT 2007).

Cape Fear River

As with Albemarle and Pamlico Sounds, the ASSRT (2007:74) cautioned that underreporting of bycatch, in such fisheries as spiny dogfish, ocean shrimp, flounder and American shad, is "extreme." Warm water temperatures in the Cape Fear River reduce the chances of survival for Atlantic sturgeon caught in gill nets. The University of North Carolina at Wilmington's Cape Fear River Survey captured 88 Atlantic sturgeon in the Edisto River from 1997-2002, of which 25% were dead; since 2002, NCDMF has conducted the survey, with an overall mortality rate of 37% and a summer mortality rate of 49%. Bycatch mortality in this system is so high that the ASSRT (2007:77) suggested that "methods such as setting gill nets overnight as a method to capture Atlantic sturgeon should be used sparingly and under the appropriate conditions (*e.g.*, water temperature, DO concentrations)."

Winyah Bay

In Winyah Bay, carcasses of large females have been found with their ovaries (caviar) removed, suggesting poaching activity (ASSRT 2007).

Santee River

In 2007, 162 Atlantic sturgeons were reported as bycatch from the Santee River shad gill net fishery (ASMFC 2008).

Savannah River

In the Savannah River, Atlantic sturgeon are caught as bycatch in the shad fishery. Two individual commercial fishermen each caught 14 Atlantic sturgeon in the period 1990-1992, for an average of 7 Atlantic sturgeon/fisher/year (ASSRT 2007). Even relatively low bycatch mortality poses a threat to the Savannah River subpopulation because it is highly stressed and extremely depleted, with complete recruitment failure occurring in some years (ASSRT 2007).

Altamaha River

Juvenile Atlantic sturgeon from the Altamaha River are caught in the shad gill net fishery and the shrimp trawl fishery (ASSRT 2007). The ASSRT (2007) estimated, based on 1982-83 Altamaha sturgeon catch data, that the shad gill net fishery accounted for 33 mortalities of this subpopulation annually. Because the subpopulation has since increased, it is likely that this bycatch mortality number has also since increased (ASSRT 2007). In 2007, 2 Atlantic sturgeon were reported as bycatch in the shad set-net fishery (ASMFC 2008).

Although Atlantic sturgeon mortality from trawls is relatively low in the north, longer trawl durations and higher water temperatures in the South Atlantic lead to higher mortality rates. The ASMFC Stock Assessment assumed a coast-wide 5% mortality rate for Atlantic sturgeon caught in trawls, indicating that the south Atlantic rate is higher (ASSRT 2007).

C. Predation and Disease

1. Predation

Documented predators of sturgeon generally include sea lampreys, gar, striped bass, common carp, northern pike minnow, channel catfish, smallmouth bass, walleye, grey seal, fallfish and sea lion (ASSRT 2007). The introduction of flathead catfish may impair anadromous fish conservation and restoration programs in the Delaware and Susquehanna basins (ASSRT 2007). This concern has been expressed by fishery management agencies for south Atlantic river basins where flathead catfish are firmly established and have reached significant biomass, altering native fish assemblages and biomass in the process. Although there is no current evidence that predation on Atlantic sturgeon is elevated above "natural" levels, predation even at "natural" levels may affect the viability of populations already depleted to low numbers by other causes.

2. Disease

Atlantic sturgeon have been observed by the FWS Northeast Fisheries Center - Fish Health Section ("NEFC FHS") with diseases thought to be caused by *Streptococcus* sp.; *Vibrio* sp.; *Aeromonas hydrophila*; *Serratia liquqefaciens*; *Vibrio anguillarum*; *Flavobacterium columnare*; *Aeromonas salmonicida*; and *Pasteurella haemolytica*. The NEFC FHS also documented several cases of swim bladder overinflation with unknown cause, as well as an unidentified systemic fungus infection (ASSRT 2007).

The ASSRT (2007) expressed concern that sturgeon pathogens might be introduced through commercial aquaculture operations and that no federal laws regulate transport or require inspection of non-salmonid fish or eggs. Atlantic sturgeon are suspected to be vulnerable to the white sturgeon iridovirus, which has been shown to cause significant mortalities in white sturgeon. The ASSRT warned that import of carrier sturgeon from the West Coast could imperil Atlantic sturgeon populations. The ASSRT also noted that the ASMFC Interstate Fishery Management Plan for Atlantic sturgeon recommends certification of sturgeon aquaculture operations as disease-free; there are no reports of such certification being done.

Parasites that affect Atlantic sturgeon in the United States include *Deropristis hispida*, which causes Distomiasis disease; *Nitzchia sturionis*; *Argulus* sp.; *Chilodonella; Ichthyobodo* (Costia), *Trichodina*; *Colponema*; and *Hexamita*. According to the ASSRT (2007), specific findings to date of parasitic infections in Atlantic sturgeon include the following. the ectoparasite *Argulus* sp. commonly infests juvenile Atlantic sturgeon in Georgia and South Carolina and has also been found in a Hudson River broodstock adult Atlantic sturgeon; Atlantic sturgeon captured in Raritan Bay, New Jersey in the 1970's had Distomiasis disease due to infestation with the digenetic trematode *Deropristis hispida*; and an adult Atlantic sturgeon captured from the main stem of the Chesapeake Bay in 2006 had a *Nitzchia sturionis* infestation.

Concurrent physical stressors likely exacerbate the impacts of disease and parasites on Atlantic sturgeon. For example, high nutrient levels result in low dissolved oxygen levels harmful to Atlantic sturgeon, including in Chesapeake Bay, the lower Neuse River, and Pamlico Sound. High nutrient levels have also been linked to outbreaks of the toxic organism *Pfiesteria,* causing numerous significant fish kills, in these same locations.

D. Insufficiency of Existing Regulatory Mechanisms

Existing state, federal, and international regulatory mechanisms are insufficient to protect Atlantic sturgeon or provide for its recovery – the species' scarcity in and, in some cases, virtual disappearance from Atlantic coastal rivers and estuaries is ample evidence of this. The ASSRT (2007) discussed the adequacy of existing regulatory mechanisms and ultimately concluded that ESA listing was warranted for various Atlantic sturgeon DPSs. Although NMFS published a Notice of Availability for the ASSRT Report on April 3, 2007, *see* 72 Fed. Reg. 15865-01, NMFS has yet to announce any decision related to the recommendations in the ASSRT report or to take any other action intended to provide the Atlantic sturgeon with protections pursuant to the ESA.

1. State Measures

The ASFMC has the authority, pursuant to 16 U.S.C. §§ 5108-5108, to develop and issue interstate fishery management plans ("FMPs") for in-shore fisheries, which are then administered by state agencies. As discussed *supra*, the ASMFC amended the Atlantic sturgeon FMP in 1998 to impose a coastwide moratorium on the harvest of Atlantic sturgeon for 20-40 years, with a goal of establishing at least 20 year classes of adult females. NMFS promulgated regulations in 1999 to impose a similar moratorium in the EEZ. The 1998 FMP amendment requires states to monitor, assess, and annually report Atlantic sturgeon bycatch and mortality in other fisheries, but, as discussed *supra*, the ASSRT (2007:102) concluded that bycatch remains "underreported or not reported at all." Moreover, measures to reduce bycatch and bycatch mortality are not required, and have not otherwise been adequately put in place. As a result, and as discussed *supra*, Atlantic sturgeon can be caught and/or discarded without limit as incidental bycatch in fishing gear such as gillnets and trawls. The present lack of regulatory measures addressing Atlantic sturgeon bycatch creates minimal incentives to avoid or to minimize its catch as bycatch, or to even educate fisherman about the imperiled status of the species and the need for action to reduce bycatch mortality.

At this point, pursuant to the ASMFC fishing moratorium, all of the Atlantic coastal states, as well as the District of Columbia and the Potomac River Fisheries Commission, have closed Atlantic sturgeon directed fisheries and prohibited landings of Atlantic sturgeon. Various states have also listed the Atlantic sturgeon for protected status, resulting in protections that, at best, have overlapped with those afforded by the ASMFC moratorium. The Commonwealth of Massachusetts lists Atlantic sturgeon as endangered and prohibits takes within rivers and three miles off the coast, and also prohibits possession. Rhode Island, Connecticut, and Pennsylvania list the Atlantic sturgeon as threatened. The lack of protected status in most states and at the federal level has limited opportunities to educate the public about the threats facing the Atlantic sturgeon and to reduce the demand for caviar resulting from poaching activities.

Regarding the effectiveness of the ASMFC moratorium, Grunwald *et al.* (2008:1111-12) emphasize that "many estuarine populations of Atlantic sturgeon remain at depressed levels, raising concerns about the eventual success of this tactic." The ASMFC itself agrees "that there is general consensus that natural stock rebuilding has not occurred and most populations of Atlantic sturgeon are at depressed levels and that there is concern that additional decreases in remnant population sizes are possible if no actions are taken" (ASMFC 2007a:1).

State regulations aimed at threats to the Atlantic sturgeon other than targeted fishing vary widely and are non-existent in many states. Regarding protection of Atlantic sturgeon from disease, the ASSRT (2007:82) concluded that:

> laws among the states along the eastern seaboard vary widely [and] … offer no real protection for the species over its entire range. For example, some states require a permit before any fish can be imported across their borders, while others require a permit only if a species is on their exotic species list (sturgeon are generally not on those lists). Also, some states do not regulate what fish might be reared by aquaculturists but require a permit only if the fish are to be stocked, and others have no restrictions. Permit requirements by the states are aimed principally at preventing introduction of non-native species and generally do not involve a fish health component.

Habitat protection and restoration efforts remain insufficient as well. For example, according to the ASSRT (2007):

- The Hudson River Estuary Management Action Plan, adopted by the NYSDEC in May 1996 with the goal of protecting, restoring and enhancing the productivity and diversity of natural resources of the Hudson River, has to date primarily resulted in data-gathering, grants for educational projects and planning, and limited open space conservation;

- The Roanoke Rapids and Gaston Dams Fishway Prescriptions, completed in 2006, does not benefit Atlantic sturgeon due to the lack of safe and effective fish passages for this species. The Department of Commerce is also not requiring fishway prescriptions for anadromous fish. *See* Roanoke Rapids and Gaston 2009 FERC License Appendix A: Section 18 Fishway Prescriptions, available at http://dom.com/about/stations/hydro/hydropower-license.jsp (accessed June 3, 2009);

- The James River Atlantic Sturgeon Restoration Plan, begun in 2005, appears to have not yet been formally approved by regulatory agencies. Those portions of the plan that have been implemented are focused on information gathering; and

- As discussed *supra*, the Penobscot Accord, approved in 2004 and which provides the Penobscot River Restoration Trust the ability to buy and decommission or remove the Veazie, Great Works and Howland dams on the Penobscot River, remains without adequate funding. Moreover, the Penobscot Accord is focused on the protection and conservation of Atlantic salmon, herring, and American eel, not Atlantic sturgeon.

Overall, the ASSRT (2007:104) concluded that:

> none of the current conservation efforts underway was considered to improve the status of the species to such an extent that a listing determination should be re-evaluated. The majority of the conservation efforts did not describe the threats to Atlantic sturgeon subpopulations in question and how these threats would be reduced or eliminated. Conservation efforts lacked recovery objectives or the appropriate steps to reduce threats, and they did not quantify performance measures for both compliance and effectiveness.

Similarly, Wirgin *et al.* (2007:1216) noted that Atlantic sturgeon subpopulations have not recovered to anything near their historical abundances "despite a patchwork of state-imposed regulatory measures." Grunwald *et al.* (2008:1111) stated that the "mosaic" of state regulations put in place to restore Atlantic sturgeon to a "goal of 10% of historic abundances in 1890" have "largely failed."

2. Federal Measures

The Magnuson-Stevens Act, 16 U.S.C. §§ 1801 *et seq.*, authorizes regional fishery management councils to prepare FMPs for conserving and managing federally-managed fisheries in the EEZ. For such federally-managed fish stocks, overfishing is not allowed and fish stocks that are already overfished must be rebuilt within statutorily-prescribed time frames. However, and even though, as noted *supra*, NMFS has prohibited targeted Atlantic sturgeon fishing in the EEZ, the species is not managed under a federal FMP and thus is not subject to the MSA's requirements concerning overfishing and rebuilding depleted fisheries.

Federal FMPs must establish standardized reporting methods for bycatch and include "practicable" measures to minimize bycatch and bycatch mortality. It is widely recognized that bycatch reporting is inadequate with respect to most non-federally managed fish species, particularly when relatively rare like Atlantic sturgeon. In addition, in part because bycatch reduction and bycatch mortality reduction is not required, FMPs implemented pursuant to the MSA do not currently contain any provisions relating to Atlantic sturgeon and, to the best of Petitioner's knowledge, none are currently proposed for future implementation.

The MSA also requires regional fishery management councils to designate "essential fish habitat" for federally-managed stocks. But because they are not federally-managed, the Atlantic sturgeon is not subject to this requirement (although it should be noted that the South Atlantic Fishery Management Council has designated essential fish habitat for anadromous species, including Atlantic sturgeon). Under 1996 amendments to the MSA, regional councils are required to comment on activities likely to substantially affect the habitat of anadromous fishery resources, but, to date, such authority has been sparingly used and has not, based on the information provided by the ASSRT (2007) and to the best of Petitioner's knowledge, resulted in meaningful modification of any projects or activities with adverse effects on Atlantic sturgeon habitat.

The Framework for the Management and Conservation of Paddlefish and Sturgeon Species in the United States, issued in 1993 by the National Paddlefish and Sturgeon Steering Committee, suggests a framework for the conservation of eight species of paddlefish and sturgeon, including Atlantic sturgeon. However, it has no regulatory force and is rather intended to encourage partnerships among entities interested in conserving sturgeon.

Various federal laws and regulations contain requirements and provisions relating to threats to the Atlantic sturgeon's habitat, including resulting from poor water quality, dredging, and/or altered water flows. As detailed *supra* and further discussed below, however, such regulatory mechanisms have failed to adequately address these habitat threats.

The federal Clean Water Act ("CWA"), 33 U.S.C. §§ 1251-1387, authorizes the EPA and states with delegated CWA programs to limit the discharge of pollutants into navigable waters. The CWA has produced notable progress in reducing discharges of toxic pollutants from industrial sources, but is widely-recognized to have not adequately regulated nutrients and toxic pollutants originating from non-point sources. The CWA's Section 404 also requires entities to obtain a federal permit from the ACOE before discharging dredged or fill material into navigable waters; section 10 of the Rivers and Harbors Act of 1899 similarly requires issuance of ACOE permits in order to place structures in navigable waters or to conduct excavation or filling activities in navigable streams. Such permits, which are routinely granted, sometimes contain restrictions on the timing and location of dredging operations in habitats utilized by Atlantic sturgeon, resulting in limited incidental benefits to the species.

The Federal Power Act ("FPA"), 16 U.S.C. §§ 791-828, has provisions for protecting and enhancing fish and wildlife affected by hydroelectric facilities regulated by FERC. Section 10(j) of the FPA requires licenses issued by FERC to include conditions for protecting, mitigating damages to, and enhancing fish and wildlife, and Section 18 requires the construction and operation of fishways. However, as the ASSRT (2007:86) noted,"[t]he lack of successful fish passage devices for Atlantic sturgeon and the degradation of upstream habitat due to impoundment of the former free-flowing river[sic], limit opportunities for [Atlantic sturgeon] to benefit from FPA fishway requirements."

The Anadromous Fish Conservation Act, 16 U.S.C. §§ 757a-757f, authorizes the Secretaries of Interior and Commerce to contract with states and other entities for the conservation, development, and enhancement of anadromous fish, primarily through research, surveys, and the construction and operation of hatcheries. It does not require measures to improve habitat or reduce bycatch or mitigate other threats facing Atlantic sturgeon. Similarly, the Fish and Wildlife Coordination Act, 16 U.S.C. §§ 661-666, authorizes the Secretaries of Interior and Commerce to advise agencies engaged in federal water project development on the potential effects of projects on fish and wildlife habitat. While the law requires construction agencies to file these reports and recommendations with requests for congressional authorization, the recommendations are not binding.

A number of federal and international laws and policies are intended to control the potential spread of fish pathogens from one geographic area to another, such as 50 C.F.R. § 16, the FWS Health Policy, and the North Atlantic Salmon Conservation Organization Williamsburg Resolution but they are focused on salmonid species and, according to the ASSRT (2007), do not protect Atlantic sturgeon. The ASMFC FMP recommends that public aquaculture facilities be certified as disease-free and that states submit annual reports regarding such certification, but, to the best of Petitioner's knowledge, this recommendation has not been acted on to date.

Finally, various federal protections exist for the shortnose sturgeon, which has been listed under the ESA since 1967. According to the ASSRT (2007), protective measures undertaken for the shortnose sturgeon may also benefit Atlantic sturgeon. Such benefits are limited for the following reasons. First, shortnose sturgeon do not occur in some rivers used by Atlantic sturgeon, such as the Tar-Pamlico, Neuse, and Roanoke rivers in North Carolina (ASSRT 2007). Second, shortnose sturgeon primarily remain in their natal rivers or estuaries and are rarely found in the continental shelf marine environment (Stein *et al.* 2004). Atlantic sturgeon, on the other hand, spend most of their adult life in the marine environment. Moreover, even within rivers where the two species do overlap, Atlantic sturgeon use different depth corridors than shortnose sturgeon and are more sensitive to certain toxins, resulting in disparate reactions to poor water quality. Finally, Atlantic and shortnose sturgeon have different spawning seasons in some regions, so that seasonal dredging restrictions aimed at protecting shortnose sturgeon spawning do not mitigate the threats to Atlantic sturgeon (ASSRT 2007). Thus, while shortnose sturgeon have been listed as endangered since 1967 and have demonstrated significant signs of recovery in many rivers, the protective measures adopted for that species have not stemmed the decline of Atlantic sturgeon.

3. International

Atlantic sturgeon were listed in 1975 under CITES Appendix II (50 C.F.R. § 23.23), which is for species that may become threatened with extinction absent trade regulation. Under CITES, permits are required for transporting Appendix II-listed species internationally. CITES neither prohibits the international trade of Atlantic sturgeon nor addresses the most significant threats to its continued survival, *i.e.*, bycatch, degradation and loss of habitat, dredging and blasting, and ship strikes.

In Canada, the Department of Fisheries and Oceans in the Maritime Provinces and the provincial government in Quebec both regulate Atlantic sturgeon fishing (ASSRT 2007). As of 2006, there were 16 non-transferrable commercial licenses for directed Atlantic sturgeon harvest in Canada outside Quebec (ASSRT 2007). The legal minimum mesh size is 33 cm, the minimum size limit for fish harvest is 120 cm, and the fishery is closed during the June 1-30 spawning season (ASSRT 2007). There has been a ban on retention of sturgeon bycatch in the Maritime Provinces since 1995 (ASSRT 2007). The Quebec Ministere de l'Environnement et de la Faune regulates the Saint Lawrence River Atlantic sturgeon fishery and allows a total harvest quota of 6,000 fish along with a size limit of 100-150 cm TL (ASSRT 2007). The fishing season runs from May 1 – September 30 (ASSRT 2007). None of these measures have prevented the decline in Atlantic sturgeon along the North American east coast.

E. Other Natural or Man Made Factors

1. Impingement, Entrainment, and Water Temperature

Operations that withdraw water from rivers or other bodies or water can impinge or entrain Atlantic sturgeon larvae, YOY, and small juveniles on intake screens, especially when intake structures are located in or near spawning grounds. The ASSRT (2007) determined that most if not all Atlantic sturgeon subpopulations are threatened by entrainment or impingement by commercial, agricultural, or municipal water intake structures.

In the Hudson River, six power plants overlap with Atlantic sturgeon nursery habitat (ASSRT 2007). The ASSRT (2007) determined that the Danskammer, Roseton, Lovett, and Indian Point power plants pose the greatest risk to Atlantic sturgeon. Surveys conducted from 1972-1998 reported 8 entrained sturgeon larvae and 63 impinged shortnose sturgeon. The Danskammer Point Plant averaged 4.2 – 5.2 impinged fish per year, Indian Point averaged 1.5 – 2.3 fish/year, Roseton 1.5 – 1.8 fish/year, and Bowline Point 0 – 0.9 fish/year. However, according to the ASSRT (2007), not all of the power plants conducted impingement and entrainment surveys, so the number of mortalities may be much higher.

The Delaware River subpopulation is threatened by the risk of impingement and entrainment at the Salem power plant, where juvenile shortnose sturgeons have reportedly been impinged (ASSRT 2007). This hazard will increase with use of the new LNG terminal; shipping carriers using the facility will require intake of an estimated eight million gallons of water over a 10-hour period to reach stability at the berth, plus an additional 5 to 11 million gallons of ballast water after undocking (ASSRT 2007).

The Hatch Nuclear Power Plant on the Altamaha River imperils Atlantic sturgeon via impingement on the trash racks and entrainment in the cooling water intakes (ASSRT 2007).

Facilities that release heated water also cause changes in Atlantic sturgeon habitat that can cause mortalities (ASSRT 2007). The ASSRT (2007) also concluded that the generally the “vast withdrawal of water” from Atlantic sturgeon habitat is a threat to the viability of subpopulations, although the exact nature of the threat to specific subpopulations could not be determined (ASSRT 2007:96).

2. Ship Strikes

Increased dredging in Atlantic sturgeon habitat has led to a rise in commercial and recreational boat traffic. As a result, ship strike mortalities are more common. One of the biggest concerns with ship strikes is that they frequently kill large gravid females before they are able to spawn, thereby disrupting recruitment. The Chairman of the ASMB noted that “those are probably your most valuable fish from a population recovery point of view if they’re the big, ripe females” (ASMB 2007:11).

Subpopulations in rivers with large ports and narrow waterways appear to be more vulnerable to ship strikes. Such rivers include the Delaware, James, and Cape Fear rivers (ASSRT 2007). In the Delaware, even without surveys in place, 10 adult Atlantic sturgeon mortalities from ship strikes were observed in the Delaware River in 2004, another 6 in 2005, and at least 6 in 2006. Four to 8 adult sturgeon mortalities from ship strikes are reported each spring to Delaware Fish and Wildlife. This threat will likely increase, as the new Crown Landing LNG terminal is expected to receive shipments every two to three days with a maximum of 150 shipments per year (ASSRT 2007). In the James River, ship strikes have caused Atlantic sturgeon mortalities for decades, as traffic on the James includes ships as large as ocean freighters (ASMB 2007). Five sturgeon were reported killed by commercial ships in 2005 alone (ASSRT 2007). It can be assumed that there were additional strikes that were unobserved or unreported. In the Cape Fear River, one strike is reported every five years (ASSRT 2007:91), and it is reasonable again to assume that more occur without being reported. The ASMB (2007) noted a recent uptick in the number of fatal ship strikes to Atlantic sturgeon in New York, from one or two observed fatalities per year to eight within the first eight months of 2007. Ship strikes are considered a grave threat to the Delaware and James River subpopulations in particular. The subpopulations in these rivers are small and the number of ship strikes relatively large. As the ASSRT (2007:96) concluded:

> [t]he observation of multiple suspected boat strikes in the Delaware and James rivers was considered to be a major threat to these subpopulations. The majority of mortalities observed in these rivers from potential boat strikes have been of large adult Atlantic sturgeon.

3. Aquaculture

As of 2005, there were 13 sturgeon aquaculture facilities in the United States (Waldman *et al.* 2008). Aquaculture of any sturgeon species can impact Atlantic sturgeon subpopulations. The primary concern is escapement, resulting in heightened threat of disease, hybridization, and food competition. White sturgeon escaped from an aquaculture facility in Georgia in the early 1990s and mixed with the wild population, ultimately migrating at least 150 miles downstream into Alabama (ASSRT 2007). In 2001, the Canadian Caviar Company shipped 18,000 Atlantic sturgeon sac fry to the University of Florida for use in feeding trials. Survivors were sent to four aquaculture businesses. One of these businesses, Watts Aquatics, has since gone out of business and it is unknown what happened to the Atlantic sturgeon it received (ASSRT 2007). It is possible that they made their way into Atlantic sturgeon habitat, which could threaten the genetic integrity of those subpopulations and spread pathogens. The ASSRT (2007) also noted that native European sturgeon in Europe recently suffered an eight fold decrease in abundance following an increase in non-native Siberian sturgeon believed to have escaped from commercial aquaculture facilities.

IV. REQUESTED LISTINGS

NMFS must list a species as "threatened" under the ESA if the species is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." *See* 16 U.S.C. § 1532(20). NMFS must list a species as "endangered" under the ESA if the species is "in danger of extinction throughout all or a significant portion of its range." *See* 16 U.S.C. § 1532(6).

Appropriate Time Frames

In choosing a time frame, *e.g.,* what is the "foreseeable future" in which a species is likely to become endangered for classification purposes, NMFS must choose a time frame that is reasonable, given the species' characteristics and the nature of the threats. *Cf. Black's Law Dictionary*, 8th ed. 2004 (definition of foreseeable is "reasonably anticipatable"). The time frame should also ensure protection of the petitioned species, and give the benefit of the doubt regarding any scientific uncertainty to the species.

The timeframe for Atlantic sturgeon should be similar to that used for other long-lived ocean species. Because global warming is one of the foremost threats to the Atlantic sturgeon, NMFS should also use a timeframe that is appropriate for such impacts and relied upon in climate modeling (such a time frame is, for example, inherently "foreseeable"). The minimum time period that meets these criteria is 100 years. The 100 year time frame was used in classifying long-lived ocean species such as Bowhead Whales, Orca Whales (for which 300 year timeframes also were analyzed), and Stellar Sea Lions, and has also been used for fish with much shorter lifespans than Atlantic sturgeon, such as Columbia River steelhead, Chinook salmon, and, most recently, the GOM DPS of Atlantic Salmon. *See, e.g.,* Atlantic Salmon GOM DPS Rule at 29356. Courts have approved use of the 100 year time-frame for multiple other species. *See*

Western Watersheds Project v .United States Fish and Wildlife Service, 535 F. Supp. 2d 1173, 1184 (D. Id. 2007) ("To be a 'threatened' species under the ESA, the sage-grouse must be 'likely' to 'be in danger of extinction' within 100 years"); *Southwest Center for Biological Diversity v. Norton*, 2002 WL 1733618, at *12 (D.D.C. July 29, 2002) (for the Queen Charlotte goshawk, the FWS determined that the goshawk would be "threatened" "if at any point in the next 100 years there is a 20 percent chance that the species would become extinct."); *Western Watersheds Project v. Foss*, 2005 WL 2002473, at *15 (D. Id., Aug. 19, 2005) (court ruled that FWS' decision not to list a plant with 64 percent chance of extinction within 100 years as threatened was untenable).

The IUCN species classification system also uses a timeframe of 100 years. For example, a species must be classified as "vulnerable" under the IUCN system if there is a probability of extinction of at least 10% within 100 years. Further, a species must be listed as "endangered" if the probability of extinction is at least 20% within 20 years or five generations, whichever is the longer (up to a maximum of 100 years).

Moreover, in planning for species recovery, agencies routinely consider a 75-200 year foreseeable future threshold (Suckling 2006). For example, the FWS used 100 years in connection with recovery of the Steller's Eider (*e.g.*, the Alaska-breeding population of the species will be considered for delisting from threatened status when it has <1% probability of extinction in the next 100 years, and certain subpopulations have <10% probability of extinction in 100 years and are stable or increasing) and 200 years in connection with recovery of the Utah prairie dog, and NMFS used 150 years in connection with the recovery of the Northern right whale (Suckling 2006).

Perhaps most importantly, the time period that NMFS uses in its listing decision must be long enough so that actions can be taken to ameliorate the threats to the petitioned species and prevent extinction. As Secor *et al.* (2002:8) noted, Atlantic sturgeon will require "decades to centuries to recover." Slowing and reversing impacts from anthropogenic greenhouse gas emissions in particular, a primary threat to the Atlantic sturgeon, will be a long-term process for a number of reasons, including the long lived nature of carbon dioxide and other greenhouse gases and the lag time between emissions and climate changes. For all these reasons, Petitioner suggests a minimum of 100 years for analyzing the threats to the continued survival of the Atlantic sturgeon.

Significant Portion of Its Range

A "significant portion of [a species'] range" (also "SPOIR") can include both current and historical habitat. *See, e.g., Northwest Ecosystem Alliance v. United States Fish and Wildlife Serv.*, 475 F.3d 1136, 1148 (9th Cir. 2007) ("major geographical areas in which it is no longer viable but once was"), citing *Defenders of Wildlife v. Norton*, 258 F.3d 1136, 1145 (9th Cir. 2001). A danger of extinction to a species within a SPOIR is sufficient to require listing. 16 U.S.C. § 1532(6); *Defenders*, 258 F.3d at 1141-42.

Cumulative Impacts of Stressors

Consistent with the ESA's requirements discussed *supra,* while each factor and each individual stressor may be discussed separately, they must be considered together in making listing decisions. To only consider them "piecewise, one or two at a time . . . is flawed because the interaction among components may yield critical insight into the probability of extinction. . . the synergism among processes—such as habitat reduction, inbreeding depression, demographic stochasticity, and loss of genetic variability—is exactly what will be overlooked by viewing only the pieces." Boyce (1992:495-6); *see also Western Watersheds Project v. Fish and Wildlife Serv.,* 535 F. Supp. 2d 1173, 1179 (D. Id. 2007) ("It is the 'cumulative impacts of the disturbances, rather than any single source, [that] may be the most significant influence on the trajectory of sagebrush ecosystems.'"). NMFS has considered cumulative risk in prior listing determinations. *See, e.g.,* Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon, 71 Fed. Reg. 17757 at 17758 (April 7, 2008) (considering the "cumulative risk from a number of different threats"); Atlantic Salmon GOM DPS Rule at 29382-83.

For Atlantic sturgeon, cumulative risk must be accounted for by considering risks posed by individual stressors and factors in the aggregate. For example, as Stein *et al.* (2004:172) point out, overfishing, dam construction, and degraded habitat have combined to decimate certain Atlantic sturgeon subpopulations. In all but two extant subpopulations, there are fewer than 300 spawning adults (ASSRT 2007). As few as 10 adult mortalities can affect the viability of such small subpopulations (ASSRT 2007). If four different individual stressors each cause 3 or 4 mortalities per year in such a subpopulation, the cumulative result is double digit mortalities. If a subpopulation can only sustain single digit mortalities but is annually faced with double digit mortalities, the subpopulation is in danger of extinction. This only becomes adequately apparent by adding together the risks posed by different stressors.

In addition, the interaction between individual stressors, and possible synergistic effects, must be considered. For example, the ASSRT (2007:91) explained that dredging compounds the risk of ship strikes: "Dredging provides safe passage for commercial shipping and recreational boat traffic. With the increase in boating traffic, the potential for sturgeon to be struck by boats is greater, and this seems to happen commonly." The ASSRT (2007:63) also determined that "[s]urvival of Atlantic sturgeon caught incidentally in gill nets is variable depending on water quality," and, according to Boesch *et al.* (2007), "the interaction between climate and anthropogenic nutrient loading [is] particularly important in determining future hypoxic events."

A. Atlantic Sturgeon as a Unitary Species Should Be Listed as an Endangered Species

For the reasons set forth in this petition, Atlantic sturgeon as a unitary species, like many other sturgeon species in the U.S. and globally, are at risk of extinction. In the U.S., nine spawning subpopulations are believed to have gone extinct, and most of the remaining spawning populations are so depleted that either their numbers cannot be reliably estimated or their continued survival is in question. All but two of the extant populations have been reduced to an estimated fewer than 300 spawning adults, a condition that is believed to make them vulnerable to failure with loss of more than ten adults annually in excess of natural mortality.[5]

As discussed *supra,* extinction of the smaller subpopulations of Atlantic sturgeon exposes the species as a whole to much greater extinction risk. For example, the ability of Atlantic sturgeon to adapt to climate change depends on genetic and geographic diversity, as maximum gene variation increases the odds that genes will carry traits amenable to climate change adaptation. The disappearance and depletion of Atlantic sturgeon subpopulations leaves the species as a whole vulnerable to being unable to adapt to changes caused by global warming.

Moreover, for the reasons set forth in this petition, Atlantic sturgeon as a unitary species is in danger of extinction throughout a significant portion of its range, including but not limited to the Delaware River, Chesapeake Bay and its tributaries, and many coastal river systems in the Carolinas and the south Atlantic. Stein *et al.* (2004:172) determined that its "[n]umbers have declined to the extent that Atlantic sturgeon must be protected to conserve the remaining populations." Accordingly, the Atlantic sturgeon should be listed as an endangered species.

B. In the Alternative, the Five Atlantic Sturgeon DPSs Should Be Listed as Threatened or Endangered

In the alternative, NMFS should list the five Atlantic sturgeon DPSs described *supra* as threatened or endangered as specified and for the reasons stated below.

1. The Gulf of Maine DPS Should Be Listed as a Threatened Species

NMFS should list the Gulf of Maine DPS of Atlantic sturgeon as threatened because this DPS is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

As discussed *supra*, the Gulf of Maine DPS historically supported at least four spawning Atlantic sturgeon subpopulations. The Piscataqua River and the Merrimack River subpopulations are considered extirpated; the Merrimack River was once an important Atlantic sturgeon fishery (ASSRT 2007). The two remaining populations in the DPS, in the Kennebec and Penobscot rivers, are estimated to have fewer than 300 spawning adults each (ASSRT 2007). For either of these two remaining subpopulations, the loss of more than approximately ten adults in excess of natural mortality levels is considered a threat to viability. South of the Gulf of Maine DPS, no known spawning subpopulations of

---

[5] Atlantic sturgeon are already protected by CITES. *See* 50 C.F.R. § 424.11(e) (recognizing CITES listing as evidence that can be used to support listing species as endangered or threatened).

Atlantic sturgeon exist until the Hudson River. Therefore, if this DPS were to become extirpated, the northern range of the Atlantic sturgeon would conceivably be the Hudson River.

The Kennebec River and its tributaries constitutes a SPOIR of this DPS. The ASSRT (2007) determined that the Kennebec River is a SPOIR based on the historical abundance of the river's subpopulation (estimated to be once more than 15,000 Atlantic sturgeon), the loss of spatial structure that would result if the subpopulation in this river were extirpated (the Kennebec constitutes half of the extant rivers in the DPS), and the genetic diversity that would be lost should extirpation occur.

The Gulf of Maine DPS of Atlantic sturgeon, including in the Kennebec River, is likely to become endangered in the foreseeable future, given its small size, declining status, and the multiple threats it faces. In the case of the Kennebec River subpopulation specifically, the ASSRT (2007) concluded that dredging, poor water quality, and bycatch each independently pose a "moderate" (level "3") risk of causing extinction to this subpopulation.[6] Since these three stressors each independently pose a moderate risk to the viability of the subpopulation, the combination of these stressors make the subpopulation likely to become endangered in the foreseeable future.

The ASSRT (2007) determined that the Kennebec River subpopulation faces an overall "moderate" (score level "3") extinction risk, which was determined by the score of three "3" scores each for dredging, poor water quality, and bycatch. This risk score is too low because it (1) does not account for the threat posed by global warming, discussed *supra*, and (2) fails to adequately take into account the cumulative impacts of the individual stressors as well as the cumulative risks from the statutory factors. Regarding the latter, the ASSRT (2007:109) stated that, as a general matter, it evaluated the "cumulative impacts" of individual stressors *within* each category/risk factor and determined that no factor scores should be elevated in risk due to cumulative impacts. But this method of analysis ignores virtually-certain cumulative threats across risk factors. Moreover, the ASSRT's determination that *no* cumulative risk exists for *any* subpopulation or DPS even within categories/risk factors is contrary to the best scientific information available.

---

[6] The extinction risk assessment methodology developed by the ASSRT is also described in Patrick *et al.* (2008). Pursuant to this methodology, fourteen individual stressors for the Atlantic sturgeon were each categorized under one of five categories corresponding to the five statutory risk factors. Team members assigned scores ranging from 1 to 5 for each individual stressor facing a subpopulation (*e.g.*, dredging or bycatch). "[F]or any given stressor, a score of 1 indicated that it was not likely to cause a population to become extinct (low risk) and a score of 5 indicated a high risk for causing extinction of the population" (ASSRT 2007:107). The scores were as follows: 1 – Low Risk; 2 – Moderately Low Risk; 3 – Moderate Risk; 4 – Moderately High Risk; and 5 – High Risk. The ASSRT used the highest individual stressor score within a category/risk factor to represent the score of the entire category/risk factor. The team then compared the five resulting category/factor scores for each DPS, and used the highest score to represent the overall level of risk to the DPS population.

Other than the Kennebec River subpopulation, the only other extant subpopulation in this DPS is in the Penobscot River, and it is so small that it was thought to be extirpated until a fisherman captured an adult Atlantic sturgeon in 2005 and a gill net survey captured seven in 2006 (ASSRT 2007). As discussed *supra*, the Penobscot subpopulation faces several significant threats to its continued survival, including a size so small that some scientists remain unsure whether it continues to spawn, recent approvals to dredge in the Penobscot Harbor along with eight other dredging projects, poor water quality, bycatch and severely degraded substrate.[7]

The ASSRT (2007:110) did not make listing recommendations for the Gulf of Maine DPS because it concluded that there were "insufficient data to allow a full assessment of the [DPS'] subpopulations." However, NMFS must make a listing determination solely "on the basis of the best scientific and commercial data available." *See* 16 U.S.C. § 1533(b)(1)(A); 50 C.F.R. § 424.11(b). Inconclusivity of existing evidence alone is no basis on which to reject a petition. *See W. Watersheds Project v. Kempthorne*, No. CV 07-161-E-MHW, 2008 WL 2338501 at 15 (D. Id. June 4, 2008) ("The FWS attempts to rely on uncertainty to justify the little consideration it gives these factors in determining the status of the species. Scientific certainty is not required to justify the listing of a species."); *Defenders of Wildlife v. Babbitt*, 958 F. Supp. 670, 679 (D.D.C. 1997) (FWS' requirement that the evidence must be conclusive violated the clear language of the ESA

---

[7] The ASSRT (2007) concluded that the Penobscot River subpopulation, like the Kennebec River subpopulation, had only a moderate risk of becoming endangered based on the highest of the individual stressor risk scores. For the reasons discussed *supra* in connection with the Kennebec River, this understates the likely cumulative risk. The ASSRT may have also given undue weight to proposals by nonprofit organizations to decommission and/or remove dams on the river, which currently block access to large portions of historical Atlantic sturgeon habitat. NMFS should not consider either future or voluntary conservation management plans in its decision whether to list a species, particularly a proposal as uncertain as this one. *See Oregon Natural Resources Council v. Daley*, 6 F. Supp. 2d 1139, 1153-55 (D. Or. 1998) (NMFS's decision not to list the Oregon Coast evolutionarily significant unit of coho salmon improperly relied on future and voluntary measures); *Center for Biological Diversity v. Morgenweck*, 351 F. Supp. 2d 1137, 1140 (D. Colo. 2004) ("the law is clear that FWS cannot consider future conservation efforts in its review of the Petition"); *Southwest Center for Biological Diversity v. Babbitt*, 939 F. Supp. 49 (D.D.C 1996) (remanding action to Secretary and instructing him to eliminate the promises of proposed future actions of the Forest Service from the listing determination); *see also* FWS & NMFS, Endangered Species Petition Management Guidance (July, 1996) at 9 (listing must be based on the "here-and-now of a species' current status" and cannot be rejected "on the basis of an unproven promise of future favorable management"); Department of the Interior Fish and Wildlife Service and Department of Commerce National Oceanic and Atmospheric Administration, Policy for Evaluation of Conservation Efforts When Making Listing Decisions, 68 Fed. Reg. 15100-02, 15115 (Mar. 28, 2003) ("PECE" policy) ("conservation efforts that are not sufficiently certain to be implemented and effective cannot contribute to a determination that listing is unnecessary or a determination to list as threatened rather than endangered"). In determining that the GOM DPS of Atlantic salmon should be listed as endangered, NMFS concluded specifically that restoration activities on the Penobscot River, including removal of the Veazie dam, did not satisfy the PECE policy and could not be relied on in the listing decision. *See* Atlantic Salmon GOM DPS Rule at 29379.

statute; “Congress repeatedly explained that it intended to require the FWS to take preventive measures *before* a species is ‘conclusively’ headed for extinction…”).

2. The New York Bight DPS Should Be Listed as an Endangered Species

The New York Bight DPS should be listed as an endangered species because it is in danger of extinction throughout all or a significant portion of its range.

As discussed *supra,* Atlantic sturgeon historically spawned in four to six rivers in the New York Bight DPS. Today, the only spawning subpopulations are in the Hudson and possibly the Delaware, meaning there are no longer spawning subpopulations of Atlantic sturgeon between the Hudson River and Maine. Moreover, of all the rivers in the DPS, only the Hudson River is considered to have a significant population (and even here, the number of spawners has shrunk by approximately 90%, according to the ASSRT (2007)).

As discussed *supra,* habitat modification, such as damming and dredging, and poor water quality, especially low DO, has been a major cause of the extirpation of Atlantic sturgeon from almost the entire range of this DPS. For example, the Taunton River suffers from extremely low DO which makes its nursery habitat unusable and likely prevented its subpopulation from recovering from direct harvest-related depletion (ASSRT 2007). Similarly, the damming of the Housatonic River restricted over 80% of its subpopulation’s historic habitat, probably causing the extirpation of that spawning subpopulation (ASSRT 2007). Bycatch is also another major threat to this DPS generally. The ASMFC (2007b) concluded that even for the Hudson River subpopulation, believed to be the largest remaining Atlantic sturgeon subpopulation, bycatch mortality exceeds those levels believed to provide for a stable population.

The ASSRT (2007) determined that the Delaware River constitutes a significant portion of this DPS’ range. Genetic data shows that the Delaware River subpopulation has the “distinct genetic signature of a remnant population” (ASSRT 2007:16) and mitochondrial DNA sequence and haplotype data indicate that it is “a genetically distinct population” (Wirgin *et al.* 2007:1214). The Hudson River subpopulation can be distinguished from the Delaware River subpopulation with 88% accuracy based on genetic data (ASSRT 2007). In addition, the habitats of the Delaware and Hudson rivers are ecologically distinct from one another. The Delaware River has ecological characteristics that, for example, produced a much larger historic abundance of Atlantic sturgeon than the Hudson River. Indeed, the Delaware River once supported the largest stock of Atlantic sturgeon in the U.S., with an estimated over 180,000 spawning females (ASSRT 2007). Its spawning habitat is less a “river” and more a tidal estuary. The subpopulation is believed to have adapted to its environmental setting with unique genetic and behavioral evolution, developing and retaining its own genetic signature and consistently homing to its own spawning grounds. If it is extirpated, critical spatial structure of the taxon will be lost.

The Delaware River Atlantic sturgeon subpopulation is in danger of extinction. It has declined from an estimated more than 180,000 spawning adults to what is estimated to be fewer than 300, a decline of 99.8 percent (ASSRT 2007). The ASSRT (2007:1088) warned specifically that the Delaware River subpopulation has been "declining rather rapidly over the last 20 years," and that "[p]opulation estimates based on mark and recapture of juvenile Atlantic sturgeon declined from 5,600 juveniles in 1991 to less than 1,000 in 1995 and voluntary logbook reporting declined from 32 fish/effort hr in 1991 to only 2 fish/effort hr in 2004."

While over-harvesting caused the initial decline in the Delaware River Atlantic sturgeon subpopulation, bycatch, ship strike mortalities, water pollution, and dredging have since played roles in the continuing decline, as discussed *supra*. The ASSRT (2007) concluded that ship strikes alone pose a moderately high (level "4") extinction risk to the Delaware River Atlantic sturgeon subpopulation. Dredging (which resulted in the loss of one of the subpopulation's two spawning sites), bycatch, and poor water quality each independently pose a moderate (level "3") extinction risk (ASSRT 2007). As discussed *supra*, for a population size of 300 or less adult Atlantic sturgeon, the estimated size of the Delaware River subpopulation, the loss of even single digit numbers of adult sturgeon annually to human-caused mortality threatens continued viability. The Delaware River subpopulation is likely incurring mortality above this level. There are an estimated 6-10 annual mortalities from ship strikes alone (a number that will likely increase with the new LNG terminal planned for Logan, NJ) (ASSRT 2007). There are additional mortalities from dredging and bycatch; in 2007 alone, it was estimated that approximately 400 Atlantic sturgeon were caught as bycatch in Delaware Bay fisheries (ASMFC 2008). Accordingly, this portion of the range must be classified as a SPOIR and the New York Bight DPS listed as an endangered species.

The ASSRT (2007:111) recommended that the New York Bight DPS be listed only as a threatened species, based on the Delaware River SPOIR having "a moderately high risk (>50% chance) of becoming endangered in the next 20 years, due to the loss of adults from ship strikes." But, as discussed *supra*, this listing recommendation failed to adequately take into account cumulative risks and to consider the likely adverse effects of global warming.

In addition, the ASSRT's recommendation was based on a too-restrictive interpretation of the endangered classification. As discussed *supra*, to be listed as endangered under the law, a species must be "in danger of extinction" throughout its range or a significant portion of its range. In its "extinction risk analysis," the ASSRT (2007:107-08) inserted the word "imminent" into the "endangered" definition, stating that "in danger of extinction" means "in danger of imminent extinction." The ASSRT (2007:108-09) went on to say, in this context, that "20 years is an appropriate timeframe for determining the status of a species," as it would "allow[] sufficient time (10+ years) to determine the productivity of Atlantic sturgeon subpopulations using standardized protocols (Sweka et al. 2006) and is the approximate age of maturity for Atlantic sturgeon or is approximately equal to one generation . . .". Equally significantly, the ASSRT (2007:108) also defined "in danger" as meaning "likely" or "a >50% chance" of becoming extinct.

The ASSRT's criteria for the endangered classification are inconsistent with the law. The ESA's definition of endangered does not include the word "imminent" and requiring that extinction be imminent would amount to a significant rewriting of the statutory definition, in part because it would contravene the need to protect species as soon as it can be determined that they are at risk of extinction, so that necessary measures can be taken to prevent such extinction. Certainly a timeframe of twenty years -- shorter than the lifespan of the current population of adult Atlantic sturgeon -- is far too short for assessing the danger of extinction for Atlantic sturgeon. The ESA is intended to prevent extinctions that are within the time horizon of a present population's lifespan. In other words, it is inconsistent with the ESA's purposes and goals, given that sturgeon populations will require extremely long time periods to recover, to decide that an Atlantic sturgeon DPS should not be listed as endangered until it is within 20 years of extinction, as this risks waiting until it is too late for this designation to be of help in saving the species. As discussed *supra*, a time frame of 100 years is commonly used in assessing risk in the ESA context, and is a reasonable minimum time frame for use with Atlantic sturgeon, given the species' characteristics and the nature of the threats.[8]

The statutory definition for "endangered" also does not include the word "likely"; the term is found only in the definition of "threatened" *(i.e.*, "likely to become endangered"). In other words, the law does not support what the ASSRT did: import the word "likely" into the definition of endangered and determine that there must be more than a 50% chance of extinction to justify listing as endangered. Indeed, as the ASSRT (2007:108) itself noted, other scientists and status review teams have determined that lower probabilities of extinction, such as 20%, are sufficient to demonstrate "danger of extinction" and thus endangered status.

3. The Chesapeake Bay DPS Should Be Listed as an Endangered Species

The Chesapeake Bay DPS of Atlantic sturgeon should be listed as an endangered species because it is in danger of extinction throughout all or a significant portion of its range.

As discussed *supra*, Atlantic sturgeon were once common throughout Chesapeake Bay and its tributaries. There were six spawning subpopulations and over 20,000 spawning females (ASSRT 2007). During the late 1800s, the second greatest caviar fishery in the eastern United States was in Chesapeake Bay (ASSRT 2007). However, as also discussed *supra*, the sturgeon population in the bay collapsed in the early 1900s. Four of the spawning subpopulations are now believed extinct. The only surviving spawning populations are in the James River, as well as probably the York River. These two subpopulations are so small that they were both believed to be extirpated until recently.

---

[8] Notwithstanding that 20 years is too short of time frame for assessing extinction risk to the Atlantic sturgeon, the Delaware River subpopulation is in danger of becoming extinct within this period, based on population trends and the severity of current threats.

Ongoing surveys of Atlantic sturgeon in Chesapeake have shown decreasing numbers; one survey's Atlantic sturgeon catch "declined dramatically" over the last decade, with only zero to three sturgeon per year since 1998 (ASSRT 2007:17).

Both the James River and York River constitute SPOIR of the Chesapeake Bay DPS. The ASSRT (2007) determined that the James River is a SPOIR based on the historical abundance of the subpopulation and the fact that its loss would result in the loss of spatial structure. The York River should also be considered to constitute a SPOIR, in part on the basis of the information discussed *infra* that has become available since the ASSRT report. First, a recent capture of 38 age-1 juveniles led experts to believe a small spawning population survives in this river, which would make it one of only two remaining extant spawning populations in the DPS. Second, genetic research reported subsequent to the ASSRT review indicates that York River sturgeon are genetically distinct from other subpopulations, including that in the James River.

Estimated to be at less than two percent of historic abundance, the Atlantic sturgeon subpopulations in both the James and York rivers and throughout the Chesapeake Bay DPS as a whole are in danger of extinction. As discussed *supra*, the major threats include:

- Bycatch and poaching, with monitoring showing high Atlantic sturgeon bycatch in Maryland and Virginia coastal waters and in Chesapeake Bay relative to other areas;

- Water pollution, with modeling showing available Atlantic sturgeon habitat restricted to 0-35% of the surface area during the summer as a result of a combination of low DO, water temperature, and salinity;

- Global warming, which will further exacerbate hypoxic conditions in Chesapeake Bay; and

- Ship strikes, with five mortalities documented annually in the James River alone in recent years.

The James River Atlantic sturgeon subpopulation specifically is in danger of extinction. According to the ASSRT (2007), it is estimated to be fewer than 300 spawning adults, a population level that experts believe cannot sustain more than single digit mortalities in excess of natural rates. The ASSRT (2007) concluded that there is a "moderately high" (level "4") risk that fisheries bycatch alone will cause the James River subpopulation to become extinct. The ASSRT (2007) also determined that ship strikes, dredging, and poor water quality each independently pose a "moderate" (level "3") extinction risk.

In combination, these stressors likely result in more than the threshold ten excess mortalities per year that a subpopulation as small as the James River subpopulation is believed able to sustain. According to the ASSRT (2007), ship strikes alone are estimated to result in at least five mortalities per year, and bycatch poses an even higher risk to the subpopulation than ship strikes. In addition, although the ASSRT did not provide a risk score for poaching in the James River, poaching likely accounts for additional mortalities (in 1998-99, 95 poached Atlantic sturgeon from this subpopulation were confiscated) (ASSRT 2007). Finally, while not considered by the ASSRT, global warming further imperils the survival of the James River subpopulation. These multiple threats, when considered in combination and in conjunction with the significantly-degraded water quality in the river and Chesapeake Bay as a whole, place the James River subpopulation in danger of extinction.`

The York River Atlantic sturgeon subpopulation, which is so depleted as to be almost nonexistent, is also in danger of extinction. The ASSRT (2007) concluded that bycatch alone has a moderate (level "3") risk of extirpating the York River subpopulation, and the subpopulation is additionally impacted by poor water quality. Because the York River is a SPOIR of the Chesapeake Bay DPS, this is another basis for listing the Chesapeake Bay DPS as endangered.

The ASSRT (2007) recommended that the Chesapeake Bay DPS be listed only as threatened, based on its conclusion that the James River SPOIR is threatened. The ASSRT underestimated the risks faced by Atlantic sturgeon in the James River and the York River and in the Chesapeake Bay DPS as a whole by not adequately accounting for cumulative effects of multiple stressors, not accounting for the adverse effects of global warming, and using a flawed standard for defining "in danger of extinction," as discussed *supra.*

4. The Carolina DPS Should Be Listed as an Endangered Species

The Carolina DPS of Atlantic sturgeon should be listed as an endangered species because it is in danger of extinction throughout all or a significant portion of its range.

As discussed *supra*, prior to 1890, an estimated 7,200 to 10,500 adult female Atlantic sturgeon were present within just the North Carolina portion of the DPS. Since then, abundance has declined dramatically. Two Atlantic sturgeon subpopulations in the DPS are now believed to have been extirpated. Abundance of the remaining subpopulations, each estimated to have fewer than 300 spawning adults, is estimated to be less than 3% of what it was historically.

The ASSRT (2007:113) determined that the Cape Fear, Santee, and Cooper rivers together constitute a significant portion of the Carolina DPS' range, as "loss of both the Santee-Cooper and Cape Fear River subpopulations would likely result in the loss of spatial structure within the DPS and thus, constitute a SPOIR." The ASSRT (2007) also determined that the Roanoke and the Pee Dee rivers each constitute SPOIR on the basis of their historical and current subpopulation levels. Finally, loss of the Tar, Neuse, Waccamaw, Ashley and Sampit rivers as portions of the range of this DPS would result in the loss of a large geographical area and the loss of significant spatial structure and number of gene flows and thus would constitute loss of a significant portion of the DPS' range.

The Carolina DPS is endangered throughout its entire range because there is not a single subpopulation with sufficient numbers to withstand excess (above natural) annual adult mortality greater than single digits. Despite such vulnerability, every subpopulation faces significant threats; the ASSRT (2007) ranked each subpopulation as under at least moderate extinction risk from two or more stressors. For example, the ASSRT (2007) concluded that five separate stressors each present "moderate" (level "3") risk of extinction to the Neuse River subpopulation. In addition, as discussed *supra,* this subpopulation suffers from impaired recruitment due to inaccessibility of spawning grounds, and possibly also as a result of contamination by toxics that impair reproductive function.

There is little question that the Carolina DPS is in danger of extinction throughout a significant portion of its range. In the case of the SPOIR determined for the Cape Fear, Santee, and Cooper rivers, the ASSRT (2007) concluded that there is a "moderately high" (level "4") extinction risk in this SPOIR from dams alone, labeling these rivers as the most impeded in the Atlantic sturgeon's entire range, with access blocked to 67% of the habitat in the Cape Fear River and 59% of the habitat in the Santee and Cooper rivers. The ASSRT (2007) also concluded that there are independent "moderate risks" of extinction in the Cape Fear River from poor water quality (low DO, nitrogen and mercury contamination, and fish kills) and bycatch with high mortality rates. The ASSRT (2007) determined that the Santee and Cooper subpopulations, which are so small that some scientists think they already have been extirpated, are threatened by regular dredging of the Cooper River nursery and spawning grounds, poor water quality (mercury contamination), and bycatch. According to the ASMFC (2008), 162 Atlantic sturgeon were reported in 2007 as bycatch in the Santee River shad fishery alone. In addition, the ASSRT (2007) determined that Atlantic sturgeon in the two other rivers it considered SPOIR for the DPS, the Roanoke and the Pee Dee, are under moderate threats of extinction as a result of water pollution and as a result of bycatch. Atlantic sturgeon recruitment in the Roanoke River is in decline and the Pee Dee River subpopulation is so small that experts thought it was extirpated until recently (ASSRT 2007). Finally, as discussed *supra*, the Tar, Neuse, and Waccamaw rivers have so few spawning adults that there remains concern that extinction is certain. In the Ashley and Sampit rivers, the spawning subpopulations already are extinct and the habitat is used by other subpopulations. As discussed *supra,* none of the extant spawning populations in these rivers are believed able to sustain more than single digit mortalities in excess of natural rates, but many are likely experiencing more than this due to the combined causes of mortality. For example, the ASSRT (2007) concluded that five separate stressors each present "moderate" (level "3") risks of extinction to the Neuse River subpopulation. In addition, there is impaired recruitment due to inaccessibility of spawning grounds, and probably also due to contamination by toxics that impair reproductive function (ASSRT 2007).

The ASSRT (2007) recommended that the Carolina DPS be listed as threatened, based on its conclusion that the subpopulations in the Santee/Cooper and Cape Fear rivers are threatened. The ASSRT underestimated the risks faced by Atlantic sturgeon in the

Santee/Cooper and Cape Fear rivers SPOIR, other river systems in the DPS, and the Carolina DPS as a whole by not adequately accounting for cumulative effects of multiple stressors, not accounting for the likely adverse effects of global warming, and using a flawed standard for defining "in danger of extinction," as discussed *supra.*

5. The South Atlantic DPS Should Be Listed as a Threatened Species

The South Atlantic DPS should be listed as a threatened species because it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Prior to 1890, there were an estimated 29,000 spawning female Atlantic sturgeon in the southern states (Grunwald *et al.* 2008), spread over eight distinct spawning subpopulations. Three of these subpopulations are now believed extinct. Of the five remaining subpopulations, only the Altamaha River subpopulation is estimated to have more than 300 spawning adults, and even that subpopulation is believed to barely exceed 300 adults, less than 6% of its estimated historical abundance (ASSRT 2007). The other extant populations are estimated to be at less than 1% of their historic abundance.

Genetic differentiation is high within this DPS. Based on genetic testing, for example, the Savannah and Ogeechee river subpopulations are each genetically distinct (ASSRT 2007). The Satilla River subpopulation, which constitutes the southern extent of spawning South Atlantic sturgeon, is also genetically distinct (ASSRT 2007).

As discussed *supra*, most of the subpopulations in this DPS are under severe stress. The Savannah, Ogeechee, and Satilla rivers each are estimated to have fewer than 300 spawning adults and recruitment appears to be only sporadically successful. The Savannah River's subpopulation is so small that evidence of spawning consists mainly of the capture of one ripe male in 1997. The ASSRT (2007:55) determined that dredging alone poses a level "3" extinction risk in the Savannah River, and that the nursery habitat "has been heavily impacted by diminished water quality and channelization." The proposed expansion of the Georgia Ports berth threatens to further reduce dissolved oxygen levels and affect salinity. The Savannah River also has "vitally important spawning habitat" blocked by the New Savannah Bluff Lock and Dam (ASSRT 2007:55). Finally, "because the Atlantic sturgeon subpopulation is depleted and highly stressed, any bycatch mortality could have an impact on the subpopulation" (ASSRT 2007:75-76).[9] The Ogeechee River's small spawning population is stressed by hypoxic

---

[9] Although it expressed significant concern about this subpopulation, the ASSRT only assigned extinction risk levels of "2" to the threats from water quality, bycatch, and dams. The ASSRT, however, failed to consider the effects of the stressors and risk factors in combination and also relied on 20 years as the time frame for assessing the "foreseeable future," which, as discussed *supra*, is too short a time frame for Atlantic sturgeon for ESA listing purposes. The ASSRT also may have lowered the threat score for dams based on the potential *future* development of fish passages that can be used by sturgeon.

conditions, bycatch mortalities, and a dam that impedes access to nursery habitat. The combination of these stressors results in complete recruitment failure in some years.[10] The Satilla River's spawning subpopulation is so depleted due to low DO levels that captures are rare, despite the fact that nearly all of the subpopulation's historic habitat is available for spawning. The combined loss of these subpopulations would result in the loss of spatial structure for the DPS and would be the loss of a significant portion of its range.

If Atlantic sturgeon once spawned in the St. Johns River's, as it may have, this no longer occurs. The river still serves as important nursery habitat for other subpopulations and constitutes the southern end of the range for the DPS and for Atlantic sturgeon as a whole (ASSRT 2007). However, 63% of the habitat in the St. Johns is currently inaccessible due to a dam and dredging and low DO levels further impair the habitat (ASSRT 2007).

Because this DPS is at the southernmost end of the Atlantic sturgeon's range, global warming will likely have particularly severe impacts. As discussed *supra*, juvenile sturgeon are vulnerable to increases in water temperature, and higher air temperatures and precipitation levels increase hypoxic conditions. The habitat in this DPS is already warmer than more northern habitats and allows for a smaller degree of change before surpassing the thermal range required by Atlantic sturgeon.

As with the Gulf of Maine DPS, the ASSRT (2007) did not make a listing recommendation for the South Atlantic DPS. The ASSRT (2007:114) stated that it did not make a listing recommendation for the South Atlantic DPS because "the team recognized that three of the eight historic subpopulations are likely extirpated and data is lacking for many of the other subpopulations. As a result, the ASSRT determined that available science was insufficient to allow a full assessment of these subpopulations within the [South Atlantic] DPS." However, as discussed *supra*, NMFS must make a listing decision based on the status and trends as shown in the best available science. The agency's findings that there are significant ongoing threats to the species that are not being adequately addressed are sufficient evidence on which to base a listing. *See W. Watersheds Project v. Kempthorne*, No. CV 07-161-E-MHW, 2008 WL 2338501 at 15 (D. Id. June 4, 2008). The agency is required to give "the benefit of the doubt to the species" and "consider the scientific information presently available." *See Defenders of Wildlife v. Babbitt*, 958 F. Supp. 670, 680 (D.D.C. 1997) (citing *Conner v. Burford*, 848 F.2d 1441, 1454 (9th Cir.1988)).

V. RECOVERY PLAN ELEMENTS

NMFS should establish a recovery plan for Atlantic sturgeon that addresses bycatch, habitat degradation, global warming, poaching, disease, and ship strikes, including:

---

[10] The ASSRT assigned a risk level of "3" to water quality and a level of "2" to bycatch. Even though the combination of these stressors is believed to result in sporadic total recruitment failure, the ASSRT appears not to have considered the effects in combination.

- Changes in gear deployment and gear variables, including temperature, soak time, use of tie downs, and mesh size, as recommended by the ASMFC (2007b) in gillnet fisheries believed to cause significant Atlantic sturgeon mortality;

- Mitigation and management to improve habitat and water quality, particularly in river systems in more southern states believed to no longer support spawning Atlantic sturgeon subpopulations and in areas where habitat and water quality is severely degraded, including specifically: 1) elimination of barriers to spawning habitat through dam removal or breaching, or installation of effective fish passage options; 2) operation of water control structures to provide flows beneficial to Atlantic sturgeon habitat use in lower portions of rivers (especially during the spawning season); 3) imposition of restrictions on dredging, including seasonal restrictions and avoidance of spawning/nursery habitat; and 4) mitigation of water quality parameters that are restricting sturgeon use of a river (*i.e.*, DO) (ASSRT 2007:58);

- Measures to address the current and future effects of global warming on Atlantic sturgeon, including measures to reduce nutrient loads and otherwise improve water quality conditions (Boesch *et al.* 2007; Preston 2004); and

- Enhanced implementation and enforcement of fishery restrictions, including additional research on methods of identifying caviar sources (Waldman *et al*. 2008).

VI. CRITICAL HABITAT DESIGNATION

Petitioner requests the designation of critical habitat for Atlantic sturgeon concurrent with the requested listings, as required by 16 U.S.C. § 1533(b)(6)(C). *See also* 16 U.S.C. § 1533(a)(3)(A). The Atlantic sturgeon has already vanished from many areas in its historic range. Critical habitat should encompass all known and potential spawning rivers. It should also encompass all estuarine and marine habitats in which Atlantic sturgeon are known to forage.

Critical habitat is defined by Section 3 of the ESA as: (i) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species. *See* 16 U.S.C. § 1532(5).

The designation and protection of critical habitat is one of the primary ways to achieve the fundamental purpose of the ESA, “to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved.” *See* 16 U.S.C. § 1531(b). In adding the critical habitat provision to the ESA, Congress clearly saw that species-based conservation efforts must be augmented with habitat-based measures: “It is the Committee's view that classifying a species as endangered or threatened is only the first step in insuring its survival. Of equal or more importance is the determination of the habitat necessary for that species' continued existence . . . If the protection of endangered and threatened species depends in large measure on the preservation of the species' habitat, then the ultimate effectiveness of the Endangered Species Act will depend on the designation of critical habitat.” *See* House Committee on Merchant Marine and Fisheries, H.R. Rep. No. 887, 94th Cong. 2nd Sess. at 3 (1976).

The Atlantic sturgeon will benefit from the designation of critical habitat in all of the ways described above. Designated critical habitat will allow NMFS to designate reasonable and prudent alternatives to activities that are impeding recovery but not necessarily causing immediate jeopardy to the continued survival of the species. For these reasons and as already stated, we request critical habitat designation concurrent with species listing.

VII. CONCLUSION

For all of the reasons discussed in this petition, NMFS should list Atlantic sturgeon as a whole as an endangered species. In the alternative, NMFS should list the Gulf of Maine and South Atlantic DPSs of the Atlantic sturgeon as threatened species and the New York Bight, Chesapeake Bay, and Carolina DPSs of the Atlantic sturgeon as endangered species.

VIII. LITERATURE CITED

ASMB. 2007. Proceedings of the Atlantic States Marine Fisheries Commission Sturgeon Management Board, August 14, 2007. Prepared by the Atlantic Sturgeon Management Board.

ASMFC. 2007a. Summary of the ASMFC Sturgeon Technical Committee Meeting. Manchester, NH.

ASMFC. 2007b. Estimation of Atlantic Sturgeon Bycatch in Coastal Atlantic Commercial Fisheries of New England and the Mid-Atlantic. Special Report to the ASMFC Atlantic Sturgeon Management Board.

ASMFC. 2008. Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for Shad and River Herring (*Alosa spp.)* 2007. October 17, 2008. Prepared by the Shad & River Herring Plan Review Team.

ASSRT. 2007. Status Review of Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus)*. Prepared by the Atlantic Sturgeon Status Review Team for the National Marine Fisheries Service, National Oceanic and Atmospheric Administration. February 23, 2007.

Boesch, Donald F., Victoria J. Coles, David G. Kimmel, and W. David Miller. 2007. Coastal Dead Zones & Global Climate Change: Ramifications of Climate Change for Chesapeake Bay Hypoxia. Excerpted from the full report, Regional Impacts of Climate Change: Four Case Studies in the United States. Prepared by University of Maryland Center for Environmental Science for the Pew Center on Global Climate Change.

Boyce, Mark S. 1992. Population Viability Analysis. Annual Review of Ecology, Evolution and Systematics, 23: 481-506.

Center for Integrative Environmental Research (CIER) at the University of Maryland. August, 2008. Climate Change Impacts on Maryland and the Cost of Inaction, Chapter 3.

EPA. 1997a. Climate Change and Connecticut. EPA 230-F-97-008g.

EPA. 1997b. Climate Change and Massachusetts. EPA 230-F-97-008u.

EPA. 2008. National Coastal Condition Report III.

EPA. Climate Change, Wildlife, and Wildlands Case Study: Chesapeake Bay and Assateague Island. Available at: http://www.epa.gov/climatechange/wycd/downloads /CS_Ches.pdf (accessed May 26, 2009).

Frumhoff, Peter C., James C. McCarthy, Jerry M. Melillo, Susanne C. Moser, Donald J. Wuebbles. July, 2007. Confronting Climate Change in the U.S. Northeast: Science, Impact, and Action. Northeast Climate Impacts Assessment.

Gephard, Stephen. Potential Impacts of Global Warming on Diadromous Fishes of Connecticut. CTDEP- Inland Fisheries Division, Old Lyme, CT.

Grunwald, Cheryl, Lorraine Maceda, John Waldman, Joseph Stabile, and Isaac Wirgin. 2008. Conservation of Atlantic sturgeon *Acipenser oxyrinchus*: delineation of stock structure and distinct population segments. Conservation Genetics, 9:1111-1124.

Hayhoe, K., C.P. Wake, T.G. Huntington, L. Luo, M.D. Schwartz, J. Sheffield, E. Wood, B. Anderson, J. Bradbury, A. DeGaetano, T.J. Troy, and D. Wolfe. 2007. Past and Future Changes in Climate and Hydrological Indicators in the US Northeast. Climate Dynamics, 28: 381-407.

Howarth, R.W., D.P. Swaney, E.W. Boyer, R. Marino, N. Jaworski, and C. Goodale. 2006. The influence of climate on average nitrogen export from large watersheds in the Northeastern United States. Biogeochemistry, 79: 163-186.

Intergovernmental Panel on Climate Change. 2001. Climate Change 2001: Impacts, Adaptation, and Vulnerability.

Intergovernmental Panel on Climate Change. 2007. Climate Change 2007: Impacts, Adaptation, and Vulnerability.

Kemp, W.M., W.R. Boynton, J.E. Adolf1, D.F. Boesch, W.C. Boicourt, G. Brush, J.C. Cornwell, T.R. Fisher, P.M. Gilbert, J.D. Hagy, L.W. Harding, E.D. Houde, D.G. Kimmel, W.D. Miller, R.I.E. Newell, M.R. Roman, E.M. Smith, J.C. Stevenson. 2005. Eutrophication of Chesapeake Bay: Historical Trends and Ecological Interactions. Marine Ecology Progress Series, 303: 1-29.

Kerr, L.A., W.J. Connelly, E.J. Martino, A.C. Peer, R.J. Woodland, and D.H. Secor. 2009. Climate Change in the U.S. Atlantic Affecting Recreational Fisheries. Reviews in Fisheries Science, 17(2):267-289.

NMFS. 1997. 90-Day Finding for a Petition to List the Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) in the United States as Endangered or Threatened, 62 Fed. Reg. 54018.

NMFS. 1998. Recovery Plan for the Shortnose Sturgeon. National Oceanic and Atmospheric Administration.

NMFS. February 2009. Standardized Bycatch Reporting Methodology Annual Discard Report.

Niklitschek, E.J., David H. Secor. 2005. Modeling spatial and temporal variation of suitable nursery habitats for Atlantic sturgeon in the Chesapeake Bay. Estuarine, Coastal and Shelf Science 64 (2005) 135-148.

Ordóñez, Isabel. “Everybody Into the Ocean: the race is on to turn waves, tides and currents into electrical energy,” *Wall Street Journal* 6 October, 2008.

Patrick, Wesley S., and K. Damon-Randall. 2008. Using a five-factored structured decision analysis to evaluate the extinction risk of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus)*. Biological Conservation, 141: 2906-2911.

Preston, B. L. 2004. Observed Winter Warming of the Chesapeake Bay Estuary (1949-2002): Implications for Ecosystem Management. Environmental Management, 34: 125-139.

Sardella, B.A., E. Sanmarti, and D. Kultz. 2008. The Acute Temperature Tolerance of Green Sturgeon (Acipenser medirostris) and the Effect of Environmental Salinity. Journal of Experimental Zoology, 309A: 477–483.

Secor, David H. and J.R. Waldman. 1999. Historical Abundance of Delaware Bay Atlantic Sturgeon and Potential Rate of Recovery. Pages 203-216 In Musick, J. ed. Life in the Slow Lane: Ecology and Conservation of Long-Lived Marine Animals. American Fisheries Society Symposium 23.

Secor, D. H., P.J. Anders, W. Van Winkle, and D.A. Dixon. 2002. Can We Study Sturgeons to Extinction? What We Do and Don't Know about the Conservation of North American Sturgeons. Pages 3-12 In: Van Winkle, W., Anders, P., Dixon, D. and Secor, D. eds. Biology, Management and Protection of North American Sturgeons. American Fisheries Society Symposium 28.

Stein, Andrew B., Kevin D. Friedland, and Michael Sutherland. 2004. Atlantic Sturgeon Marine Bycatch and Mortality on the Continental Shelf of the Northeast United States. North American Journal of Fisheries Management, 24:171-183.

Suckling, K. F. 2006. Federal endangered species recovery plans employing a 75-200 year foreseeable future threshold. January 21, 2006.

United States Department of the Interior, Office of the Solicitor. March 16, 2007. The Meaning of "In Danger of Extinction Throughout All or a Significant Portion of its Range." Memo to Director of U.S. Fish and Wildlife Service, M-37013.

Waldman, J. R., P. Doukakis, and I. Wirgin. 2008. Molecular Analysis as a Conservation Tool for Monitoring the Trade of North American Sturgeons and Paddlefish. Journal of Applied Ichthyology, 24 (Suppl. 1): 20–28.

Wirgin, Isaac, C. Grunwald, J. Stabile, and J. Waldman. 2007. Genetic Evidence for Relict Atlantic Sturgeon Stocks along the Mid-Atlantic Coast of the USA. North American Journal of Fisheries Management 27: 1214-1229.

Ziegeweid, Jeffrey R., Cecil A. Jennings, and Douglas L. Peterson. 2008. Thermal Maxima for Juvenile Shortnose Sturgeon Acclimated to Different Temperatures. Environmental Biology of Fishes, 82:299–307.