C M 1996/T:16
Theme Session on Anadromous and Catadromous Fish Restoration Programmes: A Time for Evaluation

Restoration of populations of *Acipenser oxyrinchus* along the Atlantic and Gulf of Mexico coasts

Waldman, John, and Isaac Wirgin

Abstract

Populations of the two subspecies of Atlantic sturgeon (*Acipenser oxyrinchus*) are found in large rivers along the Atlantic (*A. o. oxyrinchus*) and Gulf of Mexico coasts (*A. o. desotoi*) of North America. Although these populations were severely reduced because of overfishing and/or the blockage of spawning runs, their present statuses vary from those that still support limited fisheries (e.g., St. John River), to an apparently collapsing population (Hudson River), to relict-sized (e.g., Delaware River, Mobile River), to extirpated (Chesapeake Bay tributaries). There are two primary alternatives to restoring these populations: (1) eliminating harvest and allowing natural recolonization and increase, and (2) hatchery-based stocking. We recently performed genetic analyses aimed at guiding restoration efforts. Mitochondrial DNA analysis revealed strong stock structure along both coasts at the regional, and in some instances, population-specific levels. Also, the low gene flow rates estimated indicate low natural recolonization rates. Thus, the first alternative avoids the genetic risks of interstock transfer and inbreeding depression that may result from hatchery-based programs, but given the low intrinsic rates of increase and recolonization of Atlantic sturgeon, recovery may take decades, if it occurs at all. Therefore, it is imperative that the restoration approach selected be tailored to the particular circumstances and demographics of each population. It appears likely that early stocking efforts will be conservatively targeted toward reintroducing Atlantic sturgeon in systems where they are extinct, as recently occurred in the Nanticoke River of Chesapeake Bay.

Keywords: hatchery, mitochondrial DNA, restoration, reintroduction, sturgeon

John Waldman: Hudson River Foundation for Science and Environmental Research, 40 West 20th Street, New York, NY 10011, USA [tel: 212 924 8290, fax: 212 924 8325]. Isaac Wirgin, Nelson Institute of Environmental Medicine, New York University Medical Center, Long Meadow Road, Tuxedo, New York, 10987, USA [tel: 914 351 2415, fax: 914 351 5472].

Introduction

Populations of the two subspecies (Ong et al. 1996) of Atlantic sturgeon, *Acipenser oxyrinchus*, are found in large rivers along the Atlantic coast (*A. o. oxyrinchus*) from the St. Lawrence River, Canada, to the St. Johns River, Florida, and along the Gulf of Mexico coast (*A. o. desotoi*) from the Mississippi River, Louisiana, to the Suwannee River, Florida. Atlantic sturgeon are long-lived (~60 yr), late maturing fish, the females of which do not spawn every year. These life history characteristics render populations of the species particularly vulnerable to overharvest (Boreman 1996). Commercially valuable for its flesh and roe, Atlantic sturgeon was heavily fished in the late 1800's, with U.S. landings peaking in 1890 at ~3,350 metric tons. Shortly thereafter, virtually all U.S. populations crashed. Because of its present scarcity and strict harvest regulations, during 1990-1992, mean annual landings were ~82 mt—about 2% of that reported in 1890 (Smith & Clugston 1997).

The goal of the Fishery Management Plan for the Atlantic subspecies (Taub 1990) developed by the Atlantic States Marine Fisheries Commission (ASMFC) is to restore it to fishable abundance throughout its range, with fishable abundance defined as ~317 mt (10% of 1890 landings). The long-term recovery objective for the Gulf of Mexico subspecies (USFWS & GSMFC 1995) is to establish population levels that would allow its delisting (from its current federal status as a threatened subspecies) in discrete management units (e.g., populations or regional stocks). There are two primary avenues to achievement of these goals: (1) to reduce or eliminate harvests so that populations may rebuild naturally, and (2) to accelerate this process using hatchery culture. There is considerable interest in using hatcheries to supplement extant populations and to reintroduce Atlantic sturgeon to drainages where they are now extinct. Recently, both subspecies have been cultured and larger scale efforts now appear feasible. However, knowledge of the stock composition of *A. o. desotoi* was federally mandated prior to the initiation of restorative efforts based on stocking, so that native gene pools are preserved (USFWS & GSMFC 1995), and equivalent information was recommended in protocols developed for *A. o. oxyrinchus* (St. Pierre 1996). Partly to assist these initiatives, in what may be the largest genetic survey ($N > 600$) of any sturgeon species, we analyzed the population genetics of both Atlantic sturgeon subspecies.

Present status of populations

All Atlantic sturgeon populations were severely reduced from historical levels because of overfishing and/or the blockage of spawning runs (Smith & Clugston 1996). Although contamination is often listed as a contributor to declines of sturgeons (Birstein 1993, Waldman 1995), there is no firm evidence (but also little study) that it affected Atlantic sturgeon populations. On the Atlantic coast, the present status of populations (Table 1) varies from two that still support limited fisheries (St. Lawrence River, St. John River), to an apparently declining stock (Hudson River), to relict-sized (Delaware River), to extirpated (Maryland tributaries of Chesapeake Bay). Less is known about Gulf of Mexico populations (Table 1). The Suwannee River population is relatively large and well-studied, and the smaller, Choctawhatchee and Apalachicola River populations also appear to have received considerable scientific attention. However, only recently have systematic surveys of sturgeon been undertaken in the remainder of Gulf drainages (USFWS & GSMFC 1995); these surveys, in addition to anecdotal information solicited from the public, showed that many of these drainages still host small populations (USFWS & GSMFC 1995).

Population Genetics and Gene Flow

A. Stock Structure Along the Atlantic Coast

We used restriction fragment length polymorphism (RFLP) analysis of mitochondrial DNA (mtDNA) to characterize the stock structure of populations of *A. o. oxyrinchus* along the Atlantic coast, including the St. Lawrence River, Quebec; St. John River, New Brunswick; Hudson River, New York; Edisto River, South Carolina; and four rivers in Georgia; the Altamaha, Ogeechee, Savannah, and Satilla (Waldman et al. 1996 a,b). Chi-square analysis showed the eight populations could be grouped as three highly differentiated ($P < 0.0001$) stocks: (1) Canadian (St. Lawrence and St. John rivers); (2) Hudson River; and (3) southeastern (Edisto, Savannah, Ogeechee, Altamaha, and Satilla rivers). Composite haplotypes showed a clear cline among populations in genotypic diversity indices (Nei & Tajima 1981) that ranged from complete monomorphism (0.0) of the two Canadian populations to considerable polymorphism among southeastern populations (e.g., Edisto River: 0.646; Ogeechee River: 0.750). A latitudinal cline in genotypic diversity along the Atlantic coast is consistent with founder effects among northern populations that recolonized glaciated drainages from more genotypically diverse populations in southern, nonglaciated regions.

B. Stock Structure Along the Gulf of Mexico

We used RFLP analysis and sequencing analysis of the mtDNA control region to assess the stock structuring of *A. o. desotoi* populations among eight drainages extending from the Mississippi River to the Suwannee River (Stabile et al. 1996). RFLP analysis yielded eight composite haplotypes; genotypic diversity indices (Nei & Tajima 1981) ranged between 0.173 for the Choctawhatchee River sample to 0.732 for the Yellow River collection. This level of variation in genotypic diversity values may reflect varying degrees of population reduction. Significant differences ($P < 0.05$) in haplotype frequencies indicated substantial geographic structuring of sturgeon populations; results from the RFLP ($N = 164$) and sequence ($N = 141$) analyses were largely congruent. Five regional or river-specific stocks were identified (from west to east): (1) Lake Ponchartrain and Pearl River, (2) Pascagoula River, (3) Escambia and Yellow rivers, (4) Choctawhatchee River, and (5) Apalachicola, Ochlockonee, and Suwannee rivers. These results suggest strong reproductive isolation of *A. o. desotoi* stocks on at least a regional basis, and point to the inadvisibility of mixing of hatchery-reared progeny of broodstock from different Gulf rivers.

C. Mixed-Stock Analysis of the New York Bight Fishery

A targeted coastal gill net fishery for *A. o. oxyrinchus* has developed in recent years along the mid-Atlantic coast of New Jersey and New York (New York Bight). Waldman et al. (1996a) used haplotype frequency data of the Canadian, Hudson River, and southeastern stocks in a mixture model (Xu et al. 1994) to estimate the relative contributions of these stocks to a sample of Atlantic sturgeon ($N = 112$) from the fishery off coastal New Jersey. This analysis showed a 97% to 99% contribution from the Hudson River stock, with the remainder from the southeastern stock. The overwhelming contribution of the Hudson River stock was attributed both to (1) a hypothesized tendency for marine migrating Atlantic sturgeon to remain within the geographic provinces of their natal rivers (the Hudson River is within the Virginian province), and (2) to the absence of other robust Atlantic sturgeon populations within the Virginian province.

D. Gene Flow and Homing Fidelity

Most populations of sturgeons are anadromous or potamadromous and thus, migrate from marine or lake waters to rivers to spawn. However, almost nothing is known of the degree of homing fidelity shown by acipenseriforms (Wirgin et al. 1997). Although homing fidelity of fishes may be studied directly by means of mark-recapture, the relative scarcity, low fishing effort, and high value of sturgeons precludes such an approach. An alternative is to assess homing fidelity indirectly through genetic analysis (Tallman & Healey 1994).

Stabile et al. (1996) used both RFLP and sequencing analysis of mtDNA to estimate gene flow among five stocks of *A. o. desotoi* that occur in eight drainages that feed the Gulf of Mexico between Mississipi and Florida. Pairwise gene flow estimates (N_m: the number of reproducing migrants per generation) between stocks were derived from F_{st} values obtained via AMOVA analysis (Excoffier et al. 1992).

Pairwise estimates of gene flow among the Gulf stocks based on sequencing analysis ranged from 0.15 between the western (Lake Ponchartrain and Pearl River) stock and the Escambia River-Yellow River stock (central region), to 1.2 between the Escambia River-Yellow River stock and the eastern stock (Apalachicola, Ochlockonee, and Suwannee rivers). Gene flow estimates derived from RFLP analysis were even lower on average, and ranged from 0.09 between the western and Choctawhatchee River stocks to 0.66 between the western and Escambia River-Yellow River stock. For the Atlantic coast, gene flow was estimated (RFLP analysis) at 1.3 between the Hudson River and Canadian stocks, and 3.6 between the Hudson River and southeastern stocks.

These gene flow values are very low in comparison with estimates for other anadromous fishes. Estimated annual rates among populations of Pacific salmons have ranged between about 1% and 27% on an annual basis (reviewed in Adkinson 1996). Laughlin & Turner (1996) used two statistical methods to estimate N_m of striped bass, *Morone saxatilis*, among three Virginia tributaries of Chesapeake Bay; the private allele approach of Barton & Slatkin (1986) yielded an estimate of $N_m = 14.2$, whereas the F_{st} approach yielded an estimate of $N_m = 2.7$. In a mark-recapture study, Melvin et al. (1986) estimated an annual straying rate of 3% among Canadian populations of American shad, *Alosa sapidissima*.

Moreover, the low gene flow estimates for *A. o. desotoi* were obtained across populations that occur in eight rivers, the mouths of which are arrayed across little more than 500 km of coastline. Sturgeon from these rivers have the opportunity to mix in the Gulf of Mexico during winter. These mtDNA data show that despite the geographic proximity of these rivers, stocks of *A. o. oxyrinchus* generally exchange less than one female per generation, a level sufficient to permit genetic differentiation at the stock level (Adkinson 1996). Gene flow estimates also were generally higher among proximal stocks, suggesting that what straying occurs does so in 'stepping stone' fashion (Kimura & Weiss 1964) in which migrants among semi-isolated populations are exchanged chiefly with neighboring populations. If this is true for *A. o. desotoi*, then such spatially restricted straying should have contributed to the geographic structuring observed among these populations (Adkinson 1996). Low gene flow estimates indicate that natural recolonization of extinct populations of *A. oxyrinchus* proceeds slowly.

Restoration Efforts

A. Reduction in Harvests

Efforts are underway to allow A. o. *oxyrinchus* to rebuild its population abundances free of any harvest pressure. As of 1996, sturgeon fishing was banned in Maine, New Hampshire, Massachusetts, Pennsylvania, the District of Columbia, Virginia, North Carolina, and Florida. Most Atlantic sturgeon harvests were occurring in New York and New Jersey, almost exclusively on the Hudson River stock (Waldman et al. 1996a). Landings in New York increased from 7,700 kg in 1993 to almost 16,000 in 1994, and in New Jersey, landings rose from 5,900 kg in 1988 to 100,000 kg in 1990 (Waldman et al. 1996a). In light of these large increases and additional evidence of poor long-term recruitment, in March 1996, the New York State Department of Environmental Conservation declared a moratorium on the harvest of Atlantic sturgeon in New York waters. New Jersey continues to allow a small quota of Atlantic sturgeon to be harvested as a bycatch. The ASMFC has moved to implement a moratorium on further harvest of Atlantic sturgeon in all U.S. Atlantic coast waters. Along the Gulf of Mexico harvest regulations varied considerably by state until 1991; no populations of Gulf sturgeon have been fished since 1991 when it was classified as a threatened subspecies. Canadian fisheries for Atlantic sturgeon continue to be regulated, but there are no plans to ban harvest (Smith & Clugston 1997).

B. Hatchery-based Stocking

Our mtDNA analyses show that Atlantic sturgeon exhibit strong stock structure, indicating little genetic mixing of stocks. Interstock transfer should be avoided so as to prevent any dimunition of local adaptiveness. Moreover, there is concern about inbreeding depression due to the scarcity of broodstock in hatchery-based supplementation efforts of extant stocks (St. Pierre 1996). However, because the low gene flow rates estimated also indicate low natural recolonization rates, it appears likely that early stocking efforts will be targeted toward reintroducing Atlantic sturgeon in systems where they are extinct, such as Chesapeake Bay.

That hatchery-produced Atlantic sturgeon may survive in the wild was demonstrated in an experiment conducted in the Hudson River. In autumn 1994, 4,929 young-of-the-year Atlantic sturgeon that had been artificially cultured from wild Hudson River broodstock at a hatchery were stocked in the Hudson River. During 1995, surveys recovered 13 of these tagged and fin-clipped sturgeon and only 9 wild fish of the same age, indicating substantial survival of the stocked fish and poor recruitment of the wild stock (M. Bain, personal communication, Cornell University). Additional stockings in the Hudson River are not anticipated at this time. However, in July, 1996, approximately 4,000 hatchery-cultured yearling Atlantic sturgeon of Hudson River ancestry were stocked in a tributary to Chesapeake Bay, the Nanticoke River, Maryland.

Although culturing of Gulf of Mexico sturgeon continues for research purposes, no stocking of sturgeon has occurred in Gulf drainages, nor has it been determined that stocking should occur. Evaluation of the need to stock sturgeon is part of the Gulf Sturgeon Recovery/Management Plan (USFWS & GSMFC 1995); attempts will be made to first determine whether the rivers to be stocked can support the stocked fish, natural reproduction, and any progeny.

Conclusions

Atlantic sturgeon restoration efforts are at an early, but critical juncture. The two management options, i.e., (1) to reduce or eliminate harvests to allow stocks to rebuild naturally, and (2) to stock Atlantic sturgeon, offer different advantages and risks. Because Atlantic sturgeon occur in discrete stocks, these options must be exercised on a stock-specific basis. The challenge is to apply these options appropriately from the beginning because of the relatively large lag time for either action to demonstrate success. Although generation time varies with latitude, even in southern populations age at first maturity of females may be 10 or more years (Huff 1975). Such slow generation time and nonannual reproduction means that even under salubrious conditions, all Atlantic sturgeon populations have a low intrinsic rate of increase. Thus, over a short time scale, trial-by-error approaches are not feasible for sturgeon restoration; indeed, restoration efforts should proceed with considerable knowledge and foresight about the particular status and demographics of each stock.

Harvest reduction or elimination offers the benefits of being inexpensive and free of genetic risks (Busack & Currens 1995). One drawback to this approach is that rebuilding of the stock will likely be slower than it could be if stocking was to occur. Also, harvest reduction assumes that overharvest was the limiting factor of population abundance when it is possible that other factors such as habitat availability actually controlled abundance.

Stocking of hatchery-cultured fish may occur either as supplementation of existing populations or reintroduction to water bodies where extinction has occurred. Hatchery-culture offers the advantages of greater command of the restoration effort, e.g., the opportunity to control parentage, mark progeny, and to know how many fish entered the system being restored. Negatively, hatchery-based stockings have considerable financial costs, hatchery programs often become popular and are sometimes politically difficult to halt, and artificial rearing raises genetic issues of interstock transfer and inbreeding depression. At recent workshops on Atlantic sturgeon restoration, we found that there is much greater sentiment for reintroduction than for supplementation, mainly because of concerns about possible inbreeding effects. However, even reintroduction is somewhat controversial because of a lack of certainty of extinction of the native stock, the absence of knowledge of the nature of imprinting in sturgeons, uncertainty about habitat suitability, and concerns about possible competition with the Atlantic sturgeon's congener, the federally endangered shortnose sturgeon, *Acipenser brevirostrum*. Nonetheless, hatchery-based restocking in these instances is supported by the apparent absence of evidence of recolonization efforts by wild fish, in addition to the low estimated gene flow rates that indicate that homing fidelity is high and straying is rare. These observations imply that natural restoration from an initial population size of zero might be an extremely prolonged process.

Regardless of which courses of action are adopted for each stock to be restored, long-term monitoring of the success of these efforts will be crucial to learning broader lessons on how to restore Atlantic sturgeon and other sturgeon species. A major consideration in developing restoration and monitoring plans will be to obtain long-term commitments from natural resources agencies that do not normally operate within such a long range planning framework; it may be that public, private, and university consortia are best suited to the task.

Literature cited

Adkinson, M. D. 1996. Population differentiation in Pacific salmon: local adaptation, genetic drift, or the environment? Canadian Journal of Fisheries and Aquatic Sciences 52:2762-2777.

Barton, N. H., & M. Slatkin. 1986. A quasi-equilibrium theory of the distributions of rare alleles in a subdivided population. Heredity 56:409-415.

Birstein, V. J. 1993. Sturgeons and paddlefishes: threatened fishes in need of conservation. Conservation Biology 7:773-787.

Boreman, J. 1997. Sensitivity of North American sturgeon and paddlefish populations to fishing mortality. Environmental Biology of Fishes (In press).

Bowen, B. W., & J. C. Avise. 1990. Genetic structure of Atlantic and Gulf of Mexico populations of sea bass, menhaden, and sturgeon: influence of zoogeographic factors and life-history patterns. Marine Biology 107:371-381.

Busack, C. A., & K. P. Currens. 1995. Genetic risks and hazards in hatchery operations: fundamental concepts and issues. American Fisheries Society Symposium 15:71-80.

Collins, M. R., S. G. Rogers, & T. I. J. Smith. 1996. Bycatch of sturgeons along the southern Atlantic Coast of the USA. North American Journal of Fisheries Management 16:24-29.

Excoffier, L., P. E. Smouse, & J. M. Quattro. 1992. Analysis of molecular variance inferred from metric distances among DNA haplotypes: application to human mitochondrial DNA restriction data. Genetics 131:479-491.

Gilbert, C. R. 1992. Atlantic sturgeon. Pages 31-39 *in* R. A. Ashton (editor), Rare and endangered biota of Florida. Volume II, Fishes. University of Florida, Gainseville.

Huff, J. A. 1975. Life history of the Gulf of Mexico sturgeon, *Acipenser oxyrhynchus desotoi* in Suwannee River, Florida. Florida Marine Resources Publication 16.

Kieffer, M. C., & B. Kynard. 1993. Annual movements of shortnose and Atlantic sturgeons in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 122:1088-1103.

Kimura, M., & G. H. Weiss. 1964. The stepping stone model of population structure and the decrease of genetic correlation with distance. Genetics 49:561-576.

Laughlin, T. F., & B. J. Turner. 1996. Hypervariable DNA markers reveal high genetic variability within striped bass populations of the lower Chesapeake Bay. Transactions of the American Fisheries Society 125:49-55.

Melvin, G. D., M. J. Dadswell, & J. D. Martin. 1986. Fidelity of American shad, *Alosa sapidissima*, to its river of previous spawning. Canadian Journal of Fisheries and Aquatic Sciences 43:640-646.

Moser, M. L., & S. W. Ross. 1995. Habitat use and movements of shortnose and Atlantic sturgeons in the lower Cape fear River, North Carolina. Transactions of the American Fisheries Society 124:225-234.

Murawski, S. A., & A. L. Pacheco. 1977. Biological and fisheries data on Atlantic sturgeon, *Acipenser oxyrhynchus* (Mitchill). Sandy Hook Laboratory, Northeast Fisheries Center, National Marine Fisheries Service, Technical Series Report 10.

Nei, M., & F. Tajima. 1981. DNA polymorphism detectable by restriction endonucleases. Genetics 97:145-163.

Ong, T.-L., J. Stabile, I. Wirgin, & J. R. Waldman. 1996. Genetic divergence between *Acipenser oxyrinchus oxyrinchus* and *A. o. desotoi* as assessed by mitochondrial DNA sequencing analysis. Copeia 1996:464-469.

Smith, T. I. J., & J. P. Clugston. 1997. Status and management of Atlantic sturgeon, *Acipenser oxyrinchus*, in North America. Environmental Biology of Fishes (In press).

Stabile, J., J. R. Waldman, F. Parauka, & I. Wirgin. 1996. Stock structure and homing fidelity of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) based on RFLP and sequence analysis of mitochondrial DNA. Genetics (In press).

Tallman, R. F., & M. C. Healey. 1994. Homing, straying, and gene flow among seasonally separated populations of chum salmon (*Oncorhynchus keta*). Canadian Journal of Fisheries and Aquatic Sciences 51:577-588.

U.S. Fish and Wildlife Service & Gulf States Marine Fisheries Commission. 1995. Gulf sturgeon recovery plan. Atlanta, Georgia.

Van Den Avyle, M. J. 1984. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (South Atlantic)—Atlantic sturgeon. U.S. Fish and Wildlife Service, FWS/OBS-82/11.25, U.S. Army Corps of Engineers, TR EL-82-4.

Waldman, J. R. 1995. Sturgeons and paddlefishes: a convergence of biology, politics, and greed. Fisheries 20(9):20-21, 49.

Waldman, J. R., J. T. Hart, & I. I. Wirgin. 1996a. Stock composition of the New York Bight Atlantic sturgeon fishery based on analysis of mitochondrial DNA. Transactions of the American Fisheries Society 125:364-371.

Waldman, J. R., K. Nolan, J. Hart, & I. I. Wirgin. 1996b. Genetic differentiation of three key anadromous fish populations of the Hudson River. Estuaries (In press).

Wirgin, I. I., J. Stabile, & J. R. Waldman. 1997. Molecular analysis in the conservation of sturgeons and paddlefishes. Environmental Biology of Fishes (In press).

Xu, S., C. J. Kobak, & P. E. Smouse. 1994. Constrained least squares estimation of mixed population stock composition from mtDNA haplotype frequency data. Canadian Journal of Fisheries and Aquatic Sciences 51:417-425.

Table 1.—Contemporary status of Atlantic sturgeon populations on the Atlantic and Gulf of Mexico coasts. Note that status reflects our interpretation of literature cited and personal communications.

River or geographic region	Status	Information source
	Atlantic Coast	
St. Lawrence River	Commercial fishery exists near Kamouraska, Quebec	Smith & Clugston (1997)
Gulf of St. Lawrence	Generally unknown; very rare in Miramichi River	S. Courtenay, CDFO
Nova Scotia rivers	Unknown	
St. John River	Commercial fishery exists 20-50 km upriver of St. John, New Brunswick	Smith & Clugston (1997)
Kennebec/Androgscoggin System	Ripe adults and numerous subadults recently surveyed	T. Squiers, ME DMR
Penobscot River	Extremely scarce	T. Squiers, ME DMR
Merrimack River	No recent evidence of spawning; seasonally inhabited by subadults	Kieffer & Kynard (1993)
Connecticut River	No recent evidence of spawning; only subadults seen in recent years	T. Savoy, CT DEP
Hudson River	Fished commercially through 1995, moratorium on harvest in New York waters enacted in 1996; evidence exists that stock is declining	B. Young, NYSDEC
Delaware River	Estuary used seasonally by subadults of uncertain stock origin; rare young-of-the-year suggest relict stock may still exist	Craig Shirey, DEDFW

Maryland waters of Chesapeake Bay	Only rare subadults seen; no evidence of spawning over past twenty years	D. Secor, Chesapeake Biological Laboratory
Virginia waters of Chesapeake Bay	Very rare	J. Musick, VIMS
Roanoke River	No information found	
Pamlico River	Listed as an Atlantic sturgeon river	Van Den Avyle (1984)
Neuse River	Listed as an Atlantic sturgeon river	Van Den Avyle (1984)
Cape Fear River	Subadults found in moderate abundance (1990-1993)	Moser & Ross (1995)
Winyah Bay Drainage	Small to moderate population	Collins et al. (1996)
Santee River	Some subadults seen in lower river	M. Collins, SC MR
Ashepoo/Cooper/Edisto System	Reproduction occurring; numerous age-0 sturgeon observed	M. Collins, SC MR
Savannah River	Small to moderate population	Collins et al. (1996)
Ogeechee River	Tissue samples obtained from few in late 1980's; Listed as an Atlantic sturgeon river	Bowen & Avise (1990) Van Den Avyle (1984);
Altamaha River	Small to moderate population; Major producer of Atlantic sturgeon in Georgia	Collins et al. (1995) Taub (1990)
Satilla River	Little known; tissue samples obtained from few in late 1980's	Bowen & Avise (1990)
St. Marys River	Occasionally caught	Taub (1990)
St. Johns River	Historically and presently very rare; occurrences may be winter migrants from the north	Gilbert (1992)

St. Lucie River	Occasionally caught in bycatch, no historical evidence of spawning	Van Den Avyle (1984)
	Gulf of Mexico Coast	
Mississippi River and Lake Ponchartrain system	Frequently caught in recent fish surveys; also angling and commercial bycatch records	USFWS & GSMFC (1995)
Pascagoula River	Low numbers caught in recent surveys	USFWS & GSMFC (1995)
Mobile River	A few recent incidental catches	USFWS & GSMFC (1995)
Escambia River	Not common, evidence of a decline since 1980	USFWS & GSMFC (1995)
Yellow River	Low to moderate population size	USFWS & GSMFC (1995)
Choctawhatchee River	Appear to be moderately abundant	USFWS & GSMFC (1995)
Apalachicola River	Adult population numbers in the hundreds	USFWS & GSMFC (1995)
Ochlockonee River	Little information, a few fish collected in 1991	USFWS & GSMFC (1995)
Suwannee River	Population numbers in the thousands	USFWS & GSMFC (1995)