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Chapter 2

Section 2.4

Angermeier 1995

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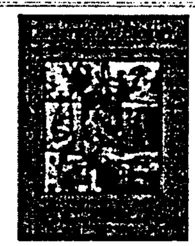

Abstract

Conservation Biology
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Volume 9 Issue 1

Ecological Attributes of Extinction-Prone Species: Loss of Freshwater Fishes of Virginia

Paul L. Angermeier

I examined patterns of extirpation among Virginia's 197 historically native freshwater fish species to address the following questions: (1) Are extinction-prone species ecologically distinct? and (2) Are distinctive features similar to those identified for extinction-prone species in terrestrial systems? All species were assigned to categories for a series of attributes reflecting geographical distribution, habitat use, trophic habits, life history, size, and reproductive behavior. Associations between species that had been extirpated and those that had not were examined for each attribute. Univariate associations were observed between extirpation and three ecological attributes: diadromy, limited physiographic range, and limited range of water sizes. Species specialized with respect to multiple ecological attributes also were especially likely to be extirpated. These associations reflected the effects of reduced habitat area and increased isolation (insularization), which are also important determinants of extinction in terrestrial systems. Multivariate analyses suggested that extirpated species were ecologically similar to each other, but were not completely distinct from the nonextirpated fauna. My results suggest that ecological knowledge of species can help identify extinction-prone species and provide a basis for proactive conservation. Current approaches to conservation, which are largely reactive and piecemeal, are inadequate to protect biodiversity. Because aquatic degradation is complex and pervasive, conservation of aquatic biodiversity requires proactive comprehensive approaches to water resource management, including emphasis on protecting the ecological integrity of entire systems.

Atributos ecológicos de las especies proclives a la extinción: la pérdida de los peces de agua dulce de Virginia

Examiné los patrones de extirpación entre 197 especies de peces dulceacuícolas nativos con fin de considerar las siguientes preguntas: 1)

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¿Tienen las especies proclives a la extinción características ecológicas distintivas? 2) ¿Son estas características distintivas semejantes aquellas identificadas en las especies terrestres proclives a las extinciones? Todas las especies fueron asignadas a categorías correspondientes a una serie de atributos que reflejan la distribución geográfica, el uso del hábitat, los hábitos tróficos, la historia natural, el tamaño y el comportamiento reproductivo. Para cada atributo, se examinaron las asociaciones entre especies que fueron extirpadas y aquellas que no lo fueron. Se observaron asociaciones univariadas entre la extirpación y tres atributos ecológicos (diadromia, rango fisiográfico limitado y limitado rango del tamaño de los hábitats acuáticos). Las especies especializadas con respecto a atributos ecológicos múltiples también fueron especialmente proclives a la extirpación. Estas asociaciones reflejaron los efectos de una superficie del hábitat reducida y de un incremento del aislamiento (insularización), los cua es también son determinantes importantes de la extinción en ecosistemas terrestres. El análisis multivariado sugirió que las especies extirpadas eran ecológicamente similares entre sí, pero no eran completamente distintas de la fauna no extripada. Mis resultados sugieren que el conocimiento ecológico de las especies puede ayudar a identificar especies proclives a la extinción y provee de una base para una conservación con iniciativa. Las estrategias de conservación actuales, que son en gran medida reactivas y puntuales, son inadecuadas para proteger la biodiversidad. Dado que la degradación acuática es compleja y omnipresente, la conservación de la biodiversidad acuática requiere estrategias de manejo de los recursos acuaticos comprensivas y con iniciativa, incluyendo un énfasis en la protección de la integridad ecológica de los sistemas en su totalidad.

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2000 Savannah River Biological Surveys for Westinghouse Savannah River Company

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30 September 2001

ASMFC 2000

Fishery Management Report No. 36
of the

Atlantic States Marine Fisheries Commission

V-519

Interstate Fishery Management Plan for American Eel

April 2000

Fishery Management Report No. 36
of the

Atlantic State Marine Fisheries Commission

Interstate Fishery Management Plan for American Eel (*Anguilla rostrata)*

April 2000

Interstate Fishery Management Plan for American Eel (*Anguilla rostrata)*

Prepared by the
American Eel Plan Development Team

And

Approved by the
Atlantic States Marine Fisheries Commission
November 1999

This document was prepared in cooperation with the Atlantic States Marine Fisheries Commission's American Eel Management Board, American Eel Technical Committee, American Eel Plan Development Team, and the American Eel Advisory Panel.

A report of the Atlantic States Marine Fisheries Commission pursuant to U.S. Department of Commerce, National Oceanic and Atmospheric Administration Award Nos. NA97 FGO 0034 and NA07 FGO 024 .

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The Atlantic States Marine Fisheries Commission developed this Interstate Fishery Management Plan for American Eel. The Plan Development Team (Team), chaired by Heather M. Stirratt, Fishery Management Plan Coordinator, ASMFC, and previously John Field, consisted of (in alphabetical order): Mr. W.-Dieter N. Busch, U.S. Fish and Wildlife Service; Mr. Lewis Flagg, Maine Department of Marine Resources; Mr. Daniel M. Kuzmeskus, U.S. Fish and Wildlife Service; Mr. John McClain, New Jersey Division of Fish, Game & Wildlife; Mr. Stewart Michels, Delaware Division of Fish and Wildlife; Mr. Charles Moore, South Carolina Department of Natural Resources; Ms. Julie Weeder, Maryland Department of Natural Resources; and Mr. John Whitehead, East Carolina University. The Team worked under the guidance of the American Eel Management Board Chaired by Dr. Lance Stewart, Governors Appointee, Connecticut, the Advisory Panel, and the Technical Committee and thanks these groups for the valuable guidance that they provided.

The Team also acknowledges the efforts of the many people who worked to create this Fishery Management Plan (FMP). The team acknowledges access to and extensive use of specific reports of value in preparing this FMP and thanks their authors. These reports included: *Maine's American Eel Species Management Plan* prepared by The Joint Committee on American Eel Management for Maine (1996); *American Eel (Anguilla rostrata) Scoping Study Report* by W.A. Richkus and K.G. Whalen, Versar, Inc. (Final Report, March 1999); *An overview of European and American eel stocks, fisheries and management issues,* by Brian M. Jessop (1997); *Distribution and Availability of Atlantic Coast Freshwater Habitats for American Eel (Anguilla rostrata)* by Busch et al. (1998); *American Eel (Anguilla rostrata) In Lake Ontario and its Tributaries: Distribution, Abundance, Essential Habitat and Restoration Requirements* by S.J. Lary and W.-D.N. Busch (1997); and *Management of the European Eel* edited by C. Moriarty and W. Dekker (1997).

The efforts of all who reviewed and edited plan drafts are appreciated. Some of those providing specific information or extensive editorial support included (in alphabetical order): Tim Brush, NHP Rep.; Alex Haro, USGS-MA; Tim Hobbs, ASMFC-intern; Brian Jessop, DFO-Canada; Capt. Lawrence Kelly, NY; Fred Kircheis, ME; Drew Kolek, MA; Sandra Lary, ME; Richard Snyder, PA; Julie Weeder, MD; John Whitehead, ECU-NC; Gail Wippelhauser, ME.

INTERSTATE FISHERY MANAGEMENT PLAN FOR AMERICAN EEL

EXECUTIVE SUMMARY

American eel *(Anguilla rostrata)* occupy a significant and unique niche in the Atlantic coastal reaches and its tributaries. Historically, American eel were very abundant in the East Coast streams, comprising more than 25 percent of the total fish biomass (Smith and Saunders 1955; Ogden 1970). The abundance of this species declined from the historic levels but remained relatively stable until the 1970s. More recently, fishermen, resource managers, and scientists postulated a further decline in abundance from harvest and limited assessment data. This resulted in the establishment of working groups by the Atlantic States Marine Fisheries Commission (ASMFC) to develop a Fishery Management Plan (FMP) for the American eel in order to protect and restore the species. This FMP is a working document that describes the goals and objectives for the species, its current status, ecological challenges affecting the species, and management options and actions needed to reach and maintain the goals. The Plan also identifies issues that need additional research support. A summary of life history, recent abundance indices, and habitat issues is included in the FMP.

GOAL

The goal of this FMP is to conserve and protect the American eel resource to ensure its continued role in the ecosystems while providing the opportunity for its commercial, recreational, scientific, and educational use. Specifically, the goal aims to:

1. Protect and enhance the abundance of American eel in inland and territorial waters of the Atlantic States and jurisdictions and contribute to the viability of the American eel spawning population; and

2. Provide for sustainable commercial, subsistence, and recreational fisheries by preventing overharvest of any eel life stage.

Primary Objectives

- Improve knowledge of eel utilization at all life stages through mandatory reporting of harvest and effort by commercial fishers and dealers, and enhanced recreational fisheries monitoring.

- Increase understanding of factors affecting eel population dynamics and life history through increased research and monitoring.

- Protect and enhance American eel abundance in all watersheds where eel now occur.

- Where practical, restore American eel to those waters where they had historical abundance but may now be absent by providing access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel.

- Investigate the abundance level of eel at the various life stages, necessary to provide adequate forage for natural predators and support ecosystem health and food chain structure.

The American eel occupies and is exploited in fresh, brackish and coastal waters along the Atlantic from the southern tip of Greenland to northeastern South America. The species has a catadromous life cycle, reproducing only in the Sargasso Sea and spending the majority of its life in freshwater. After hatching and ocean drift, initially in the pre-larval stage and then in the leptocephalus phase, metamorphosis occurs. In most areas, glass eel enter the nearshore area, although there have been reports of leptocephalus found in freshwater in Florida (J. Crumpton, Florida Game and Freshwater Fish Commission, Eustis, pers. com.). Glass eel, elvers, yellow and silver eel are found in the marine environment during part of their life cycle. Elvers, yellow and silver eel also make extensive use of freshwater systems. Therefore, a comprehensive eel management plan and comprehensive set of regulations must consider the various unique life stages and the diverse habitats used, in addition to society's interest and use of this resource.

Harvest pressure and habitat losses are listed as the primary causes of any possible historic and recent decline in abundance (Castonguay et al. 1994a and 1994b). Several factors contribute to the risk that heavy harvest may adversely affect American eel populations: (1) American eel mature slowly, requiring 7 to 30+ years to attain sexual maturity; (2) glass eel aggregate seasonally to migrate; (3) yellow eel harvest is a cumulative stress, over multiple years, on the same year class; and (4) all eel mortality is pre-spawning mortality. Habitat losses have been a chronic problem since the arrival of Europeans. Blockage of stream access, pollution, and nearshore habitat destruction limit habitat availability for eel. Castonguay et al. (1994b) indicated that oceanic changes may now also contribute to decline in eel abundance. Busch et al. (1998) estimated that diadromous fish, dependent on access to Atlantic coastal watersheds, may be hindered from reaching up to 84% of upstream habitats.

Planning and regulatory activities require information, specifically, the abundance and status of the species and its habitat. Management is made difficult by the paucity of long-term data sets describing eel abundance at any life stage. Although eel have been continuously harvested, consistent data on harvest are often not available and when available, are not good indicators of abundance because harvest is dependent on demand for eel. Where available, most of the data are of short duration and data collections were not standardized between management agencies. Few other long-term data sets are available from fish ladders, impingement sampling, research collections, and monitoring programs. In addition, changes in year-class strength are not readily recognizable because most samples of fish include fish of similar sizes but from an unknown number of year classes.

A compilation of all available information on eel fisheries and biology suggests that the data are fragmented and/or incomplete. Therefore, the FMP identifies standardized commercial and recreational regulation and surveys and monitoring programs by each state. If harvest rates are determined to have a substantial, negative impact on the American eel population, harvest restrictions will be recommended.

Each state is responsible for implementing management measures and the identification and protection of habitat within its jurisdiction to ensure the sustainability of the American eel population that resides within state boundaries. Since the American eel is one panmictic population, significant management action will have range-wide implications. The FMP suggests new funding and improved coordination, in order to effectively standardize regulations, collection of abundance data at various life stages, and evaluation of habitat and restoration.

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DEFINITIONS

LIST OF ACRONYMS AND ABBREVIATIONS

ASMFC	Atlantic States Marine Fisheries Commission
Board	American Eel Management Board
GLFC	Great Lakes Fishery Commission
FDA	U.S. Food and Drug Administration
NMFS	National Marine Fisheries Service
OMNR	Ontario Ministry of Natural Resources
Plan	American Eel Fishery Management Plan
SAC	American Eel Stock Assessment Committee
Technical Committee	American Eel Technical Committee
USFWS	U.S. Fish and Wildlife Service
MRFSS	Marine Recreational Fishery Statistics Survey

AMERICAN EEL LIFE STAGES

Pre-leptocephalus	Short-lived larval stage from hatching to the free-swimming leptocephalus stage.
Leptocephalus	A long-lived larval stage which is flattened from side to side and shaped somewhat like a willow leaf. This stage drifts and swims in the upper 300 m (1,000 ft.) of the ocean for several months, growing slowly to a length of 5-6.4 cm (2-2.5 in.).
YOY or Young of Year	Young–of-the-year fish less than or equal to 8.5 cm in length, representing a single year class
Glass eel	For the purposes of this Fishery Management Plan, glass eel are metamorphosed leptocephali that are miniature, transparent eel that range in size from 5-10 cm (2-4 in.). Metamorphosis occurs at sea, perhaps near the edge of the continental shelf. Glass eel enter estuaries and ascend rivers during winter and spring, earlier in the southern portion of the range, later in the northern portion. Glass eel ascend estuaries by drifting on flooding tides and holding position near bottom on ebb tides and also by active swimming along shore in the estuaries and above tidal influence.
Elvers	For the purposes of the Fishery Management Plan, "elver" refers to the stage after glass eel. Elvers are pigmented juvenile eel, typically less than 10 cm (4 in.) in length. This life stage may encompass several age classes.

Yellow eel	Immature eel that are dark on the back and often yellowish on the ventral surface and are of variable size that varies by latitude and/or salinity, and also by sex when that is established. They have typically spent more than one year in a stream or estuary and are greater in length than 10 cm (4 in.).
Silver or migratory eel	Following a variable period of growth as a yellow eel, which may increase with latitude, another metamorphosis occurs to form the silver eel or migratory stage. Metamorphosis may include ventral color change to silver, increase in eye diameter, non-feeding behavior and usually a thickening of skin, although this stage can be highly variable. These mature eel move downstream and seaward to spawn in the Sargasso Sea that next winter or early spring (assumed but not documented).

OTHER DEFINITIONS

Catadromous	Spawning and larval development and migration occurring in the open ocean, feeding and growth occurring in estuaries and fresh waters, and adults returning to the ocean.
Dip net	An active capture gear consisting of a rigid frame filled with netting, firmly attached to a rigid handle and manually operated by a single person.
EEZ	Exclusive Economic Zone for the U.S. coastal ocean, extending from 3 to 200 nautical miles offshore
Escape panel or Excluder	Area of mesh in capture gear that allows pre-determined smaller sizes to escape or that prevents larger sizes from entering.
Fyke Net (elver or glass)	A funnel-shaped net designed to intercept moving marine organisms and retain them in a confined space. The net is of various length from cod end to wing tips and is fitted with various size netting. For glass eel the net measures 0.3 cm (1/8 in.) mesh square measure or less.
Hoop Net	A stationary cylindrical net fitted with mesh that is placed at the bottom of a body of water. The gear includes wings or leads attached to the mouth of the net.
Panmictic	Single breeding population exhibiting random mating. Offspring from any parents capable of inhabiting any suitable habitat in any portion of the range.
Pot	A cylindrical or rectangular trap with funnels that is baited. The gear is typically made of mesh.
Sheldon Eel Trap	A box trap with netted wings used to intercept and capture glass eel or elvers.

Spear	The historically most widely known and used method for capturing eel during the early eel fisheries, often consisting of a spatula-shaped center piece with three teeth on each side, each tooth having a single barb. A 3-9 m (10-30 ft.) long wooden pole is attached to this instrument for probing the soft muddy bottom through a hole in the ice or from a boat.
Trap	Passive gear similar to but smaller than weirs. May have one or two wings facing upstream to take descending silver eel. Wings, if present, do not block entire stream and unit is considered portable.
Weir	A trapping device consisting of two wings extending from opposite shores of the stream running obliquely downstream and converging to form a funnel, to which is attached a box trap. As silver eel descend streams, the wings guide them into the box trap. This passive capture gear is semi-permanent, constructed of wood or other solid material, and usually blocks most or the entire channel.

FOREWORD

Charge to Develop a Fishery Management Plan

The Atlantic States Marine Fisheries Commission (ASMFC), at its October 1995 Annual Meeting, voted to initiate the development and implementation of a Interstate Fishery Management Plan (FMP) for American Eel. Due to commercial harvest association with horseshoe crabs, the initial charge was for a joint plan. However, this charge was modified more recently based on biological and ecological differences between the species so that the management of these two species will be addressed in separate plans. The Atlantic coastal states concluded that a coordinated, interstate plan would best address conservation and fishery issues for the American eel. ASMFC is a compact of the fifteen Atlantic Coast states, created to promote the better utilization of the fisheries (marine, shell and anadromous) along the Atlantic seaboard by the development of a joint program for the promotion and protection of such fisheries.

Development of a Public Information Document

A Public Information Document (PID) was prepared to obtain input from the public and interested commercial and recreational users on alternatives and recommendations for state management programs in the development of the American Eel Fishery Management Plan (FMP). The PID briefly discussed the American eel life history and the problems associated with the species' management, status of stocks, current ocean and riverine fisheries, and monitoring and information needs. Public hearings on the PID were held during the spring of 1997.

Purpose of this Fishery Management Plan

The American Eel Fishery Management Plan is a working document that describes the goals and objectives for the species, its current status, recent and historical trends, the ecological challenges affecting the species, management options and actions needed to reach and maintain the goals, and issues that need additional research support. A summary of life history information, recent abundance indices, and habitat issues is included. Species management plans need to be dynamic and are designed to be updated as new data are obtained. This Fishery Management Plan will undergo periodic review to ensure that it reflects any changes in species status, the latest in research and resulting changes in Goals, Objectives and Strategies based on these findings, and changes in human attitudes and needs.

Upon completion and approval of the FMP, ASMFC states are obliged to implement its requirements. In the event that a state does not completely implement an ASMFC fishery management plan, the Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA) provides that the U.S. Secretary of Commerce may impose a moratorium in that state's particular fishery. All ASMFC fishery management plans must include specific measurable standards to improve the status of the stocks and determine compliance with the standards.

A species plan aids in directing management and research efforts. It focuses attention on areas of management strength as well as those that need more development. It provides information to the public on the current knowledge concerning the species, including descriptions of ecological stresses that may limit the abundance and distribution of the species. Overall, a species management plan provides for the regulation of human activities that impact a species so that the population remains sustainable and viable. At the same time, it should allow for recreational and commercial harvest while also supporting the natural diversity of the ecological system(s) it inhabits.

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

1.1.1 Statement of the Problem

American eel has a catadromous life cycle, reproducing in the ocean and spending the majority of its life in brackish or freshwater. Any management program must, therefore, involve both marine and inland stakeholders in the management process. Spawning occurs in the Sargasso Sea, producing the larval stage (pre-leptocephalus and leptocephalus) which drifts and swims towards the continental shelf and subsequently metamorphoses into glass eel. Glass eel, elvers, yellow eel, and silver eel are found in the marine environment during part of their life cycle. Elvers, yellow eel, silver eel, and possibly glass eel also make extensive use of freshwater systems. Therefore, a comprehensive eel management plan and comprehensive set of regulations must consider the various unique life stages and the diverse habitats used, in addition to society's interest in and use of this resource.

There is both substantive data and anecdotal information that suggest segments of the American eel population have declined in recent years. The cumulative effects of multiple life stage harvest impact the American eel population. Several factors contribute to the risk that heavy harvest may adversely affect American eel populations: (1) American eel mature slowly, requiring 7 to 30+ years to attain sexual maturity (K. Oliveira, Univ. of Maine pers. comm); (2) glass eel aggregate seasonally to migrate (Haro and Krueger 1988); (3) yellow eel harvest is a cumulative stress, over multiple years, on the same year class (Richkus and Whalen 1999); (4) all eel mortality is pre-spawning mortality (McCleave 1996); (5) changes in year-class abundance are not readily recognizable because harvest abundance data include fish of similar sizes but from a number of year classes (Ritter et. al. 1997). Other factors that may contribute to a possible population decline are structures impeding upstream and downstream passage, increased predation, habitat degradation, poor water quality, and variable oceanic conditions.

American eel have been and continue to be an important resource for biodiversity and human use. The eel and elver fishery in the United States has had a long history (Crawford 1996). The eel has a wide distribution and commercial value throughout its range. The American eel is also a species whose total range includes most of the east coasts of North America, Central America, and northern South America. Significant management action, therefore, has range-wide implications. In addition, the American eel is very important to many Native American tribes, not only as a subsistence food resource, but also for its cultural and spiritual values. The Atlantic States Marine Fisheries Commission's (ASMFC) American Eel Fishery Management Plan for the Atlantic Coast of the US is intended to aid in restoring a healthy and viable American eel population while providing surplus resources for a sustainable eel fishing industry.

1.1.2 Benefits of Implementation

Members of the public have expressed concern over the proper management of American eel to ensure ecological stability. An unregulated American eel fishery and loss of habitats may result in a population collapse with resulting losses to society and to other fish and wildlife resources. Progressive coast-wide management of the American eel population would ensure the long-term viability of the population for continued harvest and would provide necessary quantities of juveniles and adults for use by other fish and wildlife resources. Conservation of the species will provide for biodiversity in natural and existing community food webs (predator-prey interactions).

1.1.2.1 Biological and Environmental

A certain amount of American eel juvenile and adult biomass must be maintained to meet the needs of those species for which eel is an important food source. Despite the range of habitats occupied by the American eel, the importance of eel as prey for other fishes, aquatic mammals, and fish-eating birds has not been well documented. However, American eel juveniles and adults are a seasonal food item of various finfish and data are available that eel are preyed on by fish-eating birds and mammals such as mink (Sinha and Jones 1967; Seymour 1974). The degree of dependence upon the various life stages of American eel by these species is unknown.

1.1.2.2 Socioeconomic

The American eel population has long been important to recreational and commercial fisheries. The fisheries are seasonal, but economically important, providing direct and indirect employment such as gear manufacturing, food processing, and shipping. Landings for American eel fluctuate widely. Much of the commercial fishery is undocumented, but may be of significant economic value (Figure 1). Although relatively few people are engaged full-time in eel fishing, part-time and casual fishermen gain an essential supplementary income. In addition, many coastal multi-species fisheries could not be sustained in the absence of eel (F. Perry 1993/pers. comm.; ASMFC Pub. Hear. Dover, DE 1997).

The significance of American eel to Native American tribes' subsistence and culture is also well established. Tribal communities have documented use of American eel in addition to other fish and game for subsistence. In some cases, seasonal tribal eel harvests have historically provided food fish for up to a year (Speck 1940). In addition, the American eel represents cultural and spiritual values to many Native American tribes by contributing to their sustenance, a focal point of Native American philosophy and lifestyle that goes well beyond the mere value of a resource as food. For example, the passing down from generation to generation of skilled knowledge on basket trap and weir designs and use is a cultural value related to the American eel resource, thus contributing to Native American sustenance (Speck 1940).

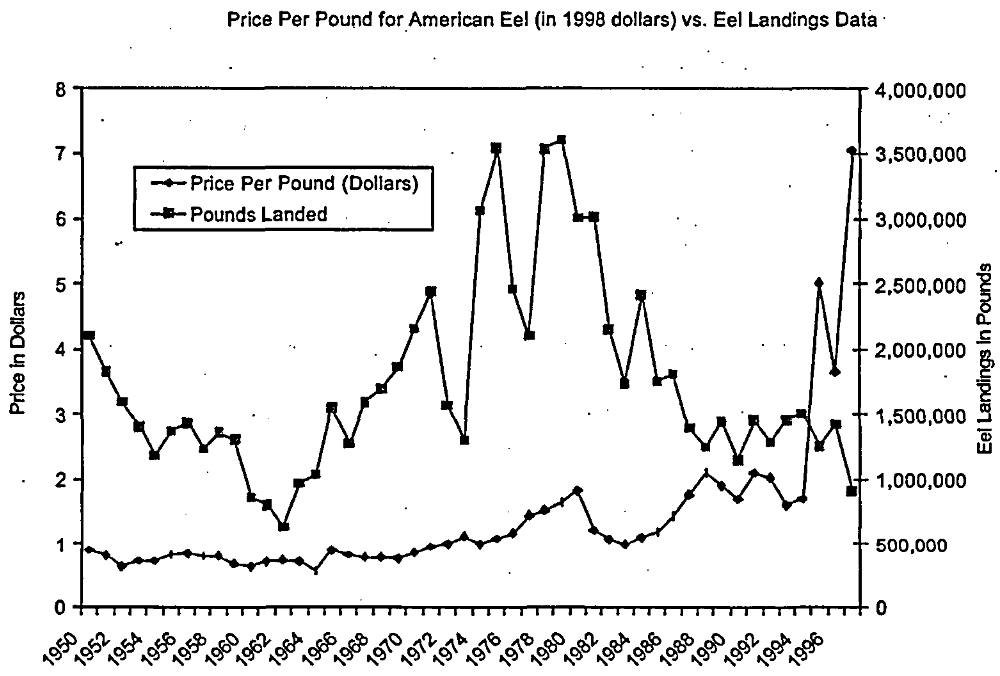


Figure 1. Price per pound for American Eel and the number of American eel pounds landed from 1950 to 1998 (NMFS, Fishery Statistics and Economics Division, 11-15-99, pers. comm.). Note that the last three years reflect the inclusion of reported glass eel landings and associated dollar values.

1.2 Description of the Resource

1.2.1 Species Life History

American eel are a unique and versatile fish species, which are highly migratory with multiple habitat requirements and feeding habits. Eel utilize a large geographic range from the entire east coast of the North and South American continents, into inland areas of the Mississippi and the Great Lakes drainages, and north into Canadian province tributaries. The species is supported throughout its range by a single source, as one spawning population in the Sargasso Sea provides all juvenile eel to be dispersed throughout its entire range each year (Figure 2). Eel have multiple habitat requirements, utilizing open oceans, large coastal tributaries, small freshwater streams, lakes and ponds. They are opportunistic feeders, requiring and utilizing multiple levels of the food chain including phytoplankton, insects, crustaceans, a multitude of fish species, and even larger prey. Individuals live for many years in freshwater and estuarine environments, before returning to the ocean as adults to reproduce once and die.

Despite the fact that in many respects American eel are an adaptable species, a multitude of known pressures on all life stages have a cumulative deleterious effect on the species as a whole. Specifically, the glass, elver, yellow and silver eel life stages are harvested commercially, which reduces their abundance at multiple life stages. This includes the adult reproductive stage since all eel mortality is pre-spawning mortality. The geographic range and habitat availability of American eel has been reduced by obstructions in migratory routes. Freshwater habitat degradation and consequential reduced food productivity levels negatively impact the freshwater life stages. It is possible that contaminants are having a negative impact on the reproductive success of American eel that grew to adulthood in contaminated habitat areas, since eel are known to have a high contaminant bioaccumulation rate (Richkus and Whalen 1999). Oceanographic changes influencing larval drift and migration could impact the overall year-class success (McCleve 1998; Castonguay 1994b), and the fact that the species consists of a single spawning population could make it particularly vulnerable to drastic oceanic variations.

It is, therefore, critical to understand the intricacies of the distinctly different life stages of the American eel. Despite this need, there is little information on any given life stage since there are few species to which the American eel life cycle could be compared, and all of the life stages are distinctly different from each other, with their own difficulties in researching. Specifically, little is known of what occurs in the last phase of the silver eel (mature) life stage; from the time the adult emigrates from freshwater, spawns and dies. The location of the spawning grounds in the Sargasso Sea has been generally identified by the appearance of larvae (leptocephali) in the plankton, but the exact location is unknown. There is also little information on the oceanic egg, leptocephali, and glass eel life stages prior to their arrival in coastal areas.

1.2.2 The Life Cycle

American eel are a catadromous fish species, spending most of their life in freshwater or estuarine environments and migrating back to the ocean to reproduce. The life cycle begins when the eggs hatch and leptocephali are carried by the Gulf Stream from the spawning grounds in the Sargasso Sea, a large portion of the western Atlantic Ocean east of the Bahamas and south of Bermuda. They are consequently dispersed by the prevailing currents along coastal areas, and the glass eel and elvers enter freshwater tributaries. Some elvers travel upstream to spend the majority of their life growing as yellow eel in rivers, streams, ponds and lakes. Mature adults migrate back downstream to return to the Sargasso Sea, where they reproduce in winter and early spring, and then die (Eales 1968; Jessop 1984).

Genetic evidence shows this species to be a panmictic population (Williams 1984) and recruitment levels throughout its range relate to the total number of eel combined from the entire range that survive to successfully reproduce. Potential changes in oceanographic conditions may have an impact on juvenile recruitment to coastal tributaries (Catonguay 1994a&b). American eel in the northern portion of their range mature at greater ages and sizes than in the southern portion, resulting in northern females being the most fecund and having a relatively long life span (Helfman 1987). More recent studies have indicated that the determination of sex may be density dependent (K. Oliviera, U. of Maine pers. comm.).

A potential threat to the overall health of the population is the non-indigenous eel swimbladder nematode (*Anguillicola crassus*). It is a parasite native to marine and freshwater areas of eastern Asia, from Japan and China to Vietnam. Its native host is the Japanese eel (*Anguilla japonica*).

The nematode has been documented to have significant negative impacts on the European eel (*Anguilla anguilla*), and on American eel in Texas and South Carolina.

1.2.3 The Life Stages

1.2.3.1 Egg

American eel spawn in the winter and early spring in the Sargasso Sea, a large portion of the western Atlantic Ocean east of the Bahamas and south of Bermuda and the eggs likely hatch in the same vicinity. Egg diameter is about 1.1 mm, however there is no information on the required environmental conditions or incubation period for the eggs. Artificially spawned Japanese eel (*Anguilla japonica*) eggs were hatched in 38-45 hours at 23 °C (Facey and Van Den Avyle 1987). American eel fecundity has been reported as a length - weight relationship that can range between 0.5 and 4.0 million eggs per female; large females (1000 mm in length), potentially produce as many as 8.5 million eggs (Facey and Van Den Avyle 1987). The relationship between eel size and fecundity can also be expressed as: $\log F = -4.29514 + 3.74418 \log TL$, $\log F = 3.2290 + 1.1157 \log W$, where F = number of eggs per female, TL = total length (mm), and W = total weight (g) (Wenner and Musick 1974). A fecundity of 0.4-2.6 million eggs was reported in females from Chesapeake Bay ranging from 50-72 cm in length (Wenner and Musick 1974). In the only other study of American Eel fecundity, 63 female eels in Maine were reported to have a fecundity of 1.4 – 21.9 million eggs for eels ranging from 45-113 cm in length (McCleve and Oliveira 1998). It is assumed that the spawning and nursery habitat that is found in the Sargasso Sea is an essential component in the hatching success.

American eel are benthic, long-lived and lipid rich. Therefore, American eel can accumulate high concentrations of contaminants, potentially causing an increased incidence of disease and reproductive impairment as is found in other fish species (Couillard et. al. 1997). An analysis of the contaminants in migrating silver eel in the St. Lawrence River showed that the highest concentrations of chemicals were found in the gonads. Concentrations of PCB and DDT were found to be 17% and 28% higher in the gonads than in the carcasses. The chemical levels in the eggs could exceed the thresholds of toxicity for larvae. Also, since the migrating females are not feeding, the chemical levels in the eggs could be even higher at hatching, increasing the likelihood of toxicity to the larvae (Hodson et.al. 1994).

Pressures/Impacts
- Contaminants may be having a negative impact on the reproductive success of American eel that grew to adulthood in contaminated habitat areas.
- Spawning habitat degradation caused by the harvest of seaweed/algae (*Sargassum sp.)* in the Sargasso Sea, the only known spawning grounds of American eel.

1.2.3.2 Leptocephalus

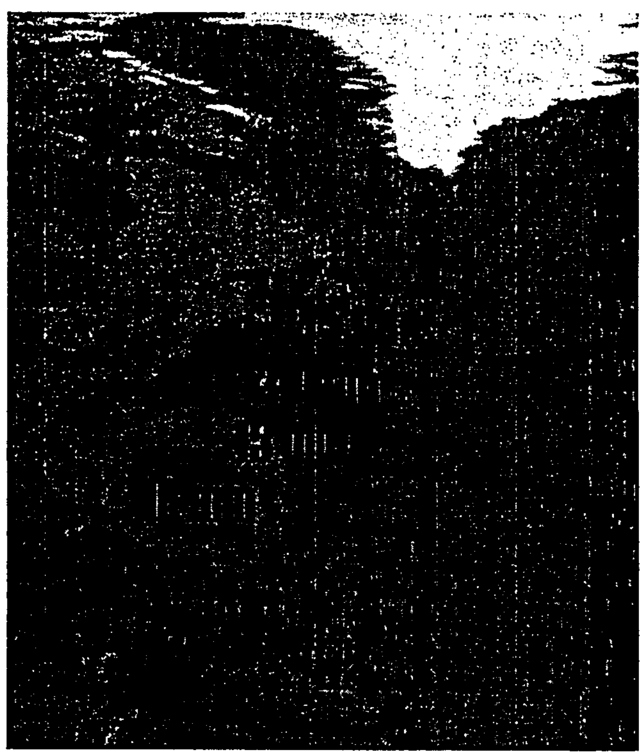
After hatching and a brief pre-larval stage, the American eel enter a larval leptocephalus stage. The larvae are shaped like a willow leaf, flattened from side to side. Leptocephali drift and swim in the upper 300 m of the water column for several months, growing slowly to a length of 5-6 cm (Kleckner and McCleave 1985). The spatial and temporal distribution of larvae is a result of oceanic circulation patterns and the swimming behavior of the larvae (Figure 2). At sea, perhaps at the edge of the continental shelf, the shape of the larvae dramatically metamorphoses into miniature transparent eel, termed glass eel.

Potential changes in oceanographic conditions may have an impact on juvenile recruitment to coastal tributaries. Catonguay (1994a) suggests two hypotheses for investigation: 1) a weak, slow Gulf Stream would cause larvae to miss the optimum period for metamorphosis and to be lost to the population when they reach the position of the stream where lateral transport would have ordinarily placed them and, 2) recent cooling events and oceanographic changes in the northwest Atlantic may have perturbed the physical processes that carry glass eel to the continent. Castonguay (1994b) also explores the indirect evidence of a weakening Gulf Stream and ways in which it may interfere with larval transport of American eel, as well as changes in the strength or location of thermal oceanfronts.

Pressures/Impacts

- Potential / exploratory harvest of leptocephali.
- Changes in oceanographic conditions, a weakening Gulf Stream and recent cooling events in the northwest Atlantic may potentially have an impact on juvenile recruitment to coastal tributaries.

Figure 2. American eel leptocehpali spatial and temporal distribution by size. Source: Uwe Kils, Rutgers U.



1.2.3.3 Glass eel

The glass eel life stage occurs when the leptocephali metamorphose at sea to resemble miniature, transparent eel. They are transparent with elongated, rounded bodies and range in length from 4.8 to 6.5 cm (Hardy 1978). They actively migrate toward land and freshwater and ascend rivers during the winter and spring. It has been demonstrated, in European glass eel, that this change in behavior was caused by the detection of the odor of freshwater, as well as temperature gradients (Facey and Van Den Avyle 1987). This migration occurs earlier in the southern portion of the range and later in the northern portion (Helfman et al. 1984; McCleave and Kleckner 1982). Glass eel ascend estuaries by drifting on flooding tides and holding position near bottom on ebb tides and also by actively swimming along shore in the estuaries and above tidal influence (Barbin et al 1994). Glass eel in estuaries and those ascending into freshwater eventually become pigmented elvers.

Pressures/Impacts

- Since artificial reproduction is not yet feasible, the intensive aquaculture industry in eastern Asia (150,000 t production) is dependent upon and supported by wild-caught glass eel and elvers (Moriarty and Dekker 1997).
- Glass eel commercial fisheries are scattered throughout the American eel's range. A limited import trade in glass eel from Europe to the United States exists for the food industry. Glass eel harvest in recent years has given rise to serious concern as to the future viability of the eel industry.
- Lack of up and downstream passage for migrating glass eel.

1.2.3.4 Elver

The elver life stage occurs when the glass eel ascend into brackish or fresh water and become pigmented, generally at 10.0 cm or less in length. At this early stage, they are active at night and burrow during the day. They move into the water column on flood tides and return to the bottom during ebb tides (McCleave and Kleckner 1982). Elvers have been shown to be attracted to the odor of brook water and decaying leaf detritus and microorganisms (Facey and Van Den Avyle 1987). Upstream migration of elvers can occur over a broad period of time from May (during peak migration) through October (Richkus and Whalen 1999). The migration occurs earlier in the southern portion of its range and later in the northern portion (Helfman et al. 1984; McCleave and Kleckner 1982).

Elvers are brown in color and are usually fully pigmented at 6.5 mm to 9.0 cm in length (Hardy 1978), although pigmented American eel have been observed less than 6.5cm in Florida (J. Crumpton, Florida Game and Fresh Water Fish Commission, Eustis pers. comm.). They eventually begin swimming upstream possibly due to changes in water chemistry and river current velocities (Facey and Van Den Avyle 1987). They grow slowly, reaching about 12.7 cm after the first year in freshwater (Bigelow and Schroeder 1953). Growth rates are highly variable, leading to considerable variation in length within age groups and poor predictability of size at age (Facey and Van Den Avyle 1987).

Pressures/Impacts

- Since artificial reproduction using mature eel is not yet feasible, the intensive aquaculture industry in eastern Asia (150,000 t production) is dependent upon and supported by wild-caught glass eel and elvers (Moriarty and Dekker 1997).
- Elver commercial fisheries are scattered throughout the eel's range in both the marine and freshwater habitat areas. Elver harvest in recent years has given rise to serious concern as to the future viability of the eel industry. The elver fishery in the United States has had a long history with wide distribution and commercial value throughout its range.
- Lack of adequate up and downstream passage for migrating elvers.

1.2.3.5 Yellow Eel

The yellow eel resembles the adult form and occurs after the elver stage. Yellow eel are usually yellow or green in color and range in size up to about 28.0 cm for males and 46.0 cm for females (Hardy 1978). They inhabit bays, estuaries, rivers, streams, lakes, and ponds where they feed primarily on invertebrates and smaller fishes (Ogden 1970). Usually by Age II, the eel have entered into the yellow phase. Depending on where they cease their upstream migration, some yellow eel reach the extreme upper portions of the rivers while others stay behind in the brackish areas (Hardy 1978, Fahay 1978). The timing and duration of yellow eel upstream migration is watershed specific and can occur over a broad period of time from March through October, peaking in May through July. Yellow eel can continue migrating until they reach sexual maturity (Richkus and Whalen 1999). In the upper St. Lawrence River, yellow eel migration is monitored between June and October, and 72.2% of the upstream migration occurs between July 18 and August 17 (Casselman et al. 1997). The growth rates of yellow eel are variable, depending on latitudinal trends (slower growth occurs in the north than in the south) and habitat productivity (slower growth occurs in freshwater than in estuaries) (Richkus and Whalen 1999).

Timing of sexual maturity in the yellow eel has been correlated with specific size ranges. Most sexually mature males are over 28.0 cm and, in the northern populations, they are older than Age 3 (Hardy 1978, Fahay 1978). Most sexually mature females are over 46.0 cm and they are older than Age 4 in the northern populations (Hardy 1978, Fahay 1978). Length-age relationships vary considerably within the northern portion of their range. The following year-class size information has been reported for Rhode Island: Age 4 total length (TL) 27-46 cm; Age 5 - TL 28-51 cm; Age 6 -TL 28-51 cm; Age 7 - TL 29-58 cm; Age 8 - TL 33-64 cm; Age 9 - TL 38-62 cm; Age 10 -37-65 cm; Age 11 - TL 46-65 cm (Bieder 1971).

There are several environmental variables that can influence sexual determination in American eel, the resulting ratios of females and males, and age at sexual maturity. In the northern portion of their range eel mature at greater ages and sizes than in the southern portion, resulting in northern females being the most fecund and having a relatively long life span (Helfman 1987). For example, numerous studies have found the St. Lawrence River-Lake Ontario eel to be exclusively female (Dutil 1987; Vladykov 1966). J. Casselman (OMNR pers. com.) also found them to be relatively older and larger. McCleave (1996) found that females are more abundant in the northern part of their range, males are more abundant in the southern part of their range, and that females grow larger and mature later than males. However, Foster and Brady (1982) found only females in Maryland where sex could be determined (N=1,000); Helfman et al. (1984) found in a Georgia river that 64% of estuarine eel were female and 94% of freshwater eel were female; Hansen and Eversole (1984) noted that females outnumbered males 23 to 1 in South Carolina. Some data suggest that there is a further isolation of the sexes by salinity. Females were found to be more prevalent in freshwater systems while males more frequently inhabit estuaries (Facey and LaBar 1981). Recent work indicates that sex determination might be influenced by density (K. Olivera, U. of Maine pers. com.). If this is the case, sex ratios may be changing towards more females throughout their range due to lower numbers of eel.

Maturation occurs in 8 to 24 years in the Chesapeake Bay Region, but may occur earlier in southern regions and later in northern regions. In the southern regions, females older than eight years old or longer than about 70 cm were rare and males older than five years old or longer than 40 cm were also rare. In contrast, maturing females in the Newfoundland study averaged 13 years of age and more than 70 cm long (Bouillon and Haedrich 1985). Female eel from Lake Champlain averaged 16 years old and nearly 70 cm long (Facey and LaBar 1981). Eel greater than age 20 were found in Lake Champlain. Males were not present, or were not captured, in the two northern studies. There is evidence that males are rarer at higher latitudes and in inland waters (Helfman et al. 1987). The size and distributional differences between the sexes led Helfman et al. (1987) to hypothesize that male and female American eel experience different natural selection pressures which result in different life history traits. They suggested that males tend to be found in the more productive habitats, closer to the spawning area, favoring rapid growth and maturity at a small size. This is a time-constrained life history strategy. Females are distributed over all suitable habitats dispersed widely through the geographic range, and slower growth to greater size and age is favored. Increased size results in increased fecundity. This is an energy-constrained life history. The evolutionary scenario hypothesized by Helfman et al. (1987) requires further research, but may be a critical concept in managing the species in different parts of the geographic range and in different habitats.

<u>Pressures/ Impacts</u>

- Yellow eel spend a lengthy period of time before reaching sexual maturity, are harvested throughout that period, and are susceptible to overharvest.
- Lack of adequate up and downstream passage for migrating juveniles.

1.2.3.6 Silver Eel

The silver eel life stage, which is the migrating and sexually mature eel, begins after a lengthy period as a yellow eel. Between the time of beginning the downstream migration and leaving the estuary for the open ocean, the yellow eel metamorphose into the adult silver eel phase, which is better suited for ocean migration (Wenner 1973, Facey and Van Den Avyle 1987). Silver eel may begin their seaward spawning migration in late summer through fall from New England tributaries (Facey and Van Den Avyle 1987). The yellow eel undergoes several physiological changes in becoming a silver eel, including: (1) a color change from yellow/green to metallic, bronze-black sheen; (2) body fattening; (3) skin thickening; (4) enlargement of the eye and change in visual pigment; (5) increased length of capillaries in the rete of the swim bladder; and (6) digestive tract degeneration (Facey and Van Den Avyle 1987). These changes have not been observed often or at all in specific state waters and are capable of variying with latitude and temperature (J. Crumpton, Florida Game and Fresh Water Fish Commission, Eustis pers. comm.). Migrating silver eel have been observed to cover 38 km in 40 hours, showing considerable vertical movements in the water column with no behavioral changes associated with diel or tidal cycles (Stasko and Rommel 1977). Little is known about the oceanic spawning migration and the means by which the spawning grounds are located are poorly understood (Miles 1968). It has been suggested that American eel use the geoelectrical fields generated by ocean currents for orientation (Rommel and Stasko 1973). The depth at which American eel migrate in the ocean has been hypothesized to vary with light intensity and turbidity (Edel 1976). Migration has been suggested to occur within the upper few hundred meters of the water column (Kleckner et al. 1983; McCleave and Kleckner 1985). However, Robins et al. (1979) photographed two *Anguilla* eel, believed to be pre-spawn American eel, at depths of about 2,000 m (on the floor of the Atlantic Ocean) in the Bahamas.

No information exists on the spawning requirements, behavior, or the exact location of spawning within the Sargasso Sea. Adult eel are believed to spawn in the winter and early spring in the

Sargasso Sea, which is a large portion of the western Atlantic Ocean east of the Bahamas and south of Bermuda. Genetic studies indicate that American eel are a single panmictic breeding population (Williams and Koehn 1984). At this time only a few published studies of fecundity of the American eel exists where the relationship between eel size and fecundity was expressed as: $\log F = -4.29514 + 3.74418 \log TL$, $\log F = 3.2290 + 1.1157 \log W$, where F = number of eggs per female, TL = total length (mm), and W = total weight (g). A fecundity of 0.4-2.6 million eggs was reported in females from Chesapeake Bay ranging from 50-72 cm in length (Wenner and Musick 1974) while Barbin and McCleave (1997) reported a range of 1.8 to 19.9 million eggs.

Pressures/Impacts

- Commercial fisheries throughout the silver eel range in freshwater and estuarine habitat areas.
- Mortality caused by hydropower turbines during the downstream migration of adults.
- Harvest of the seaweed/algae (*Sargassum sp.*) in the Sargasso Sea and potential capture of silver eel prior to reproduction.

1.2.4 Food Habits

American eel depend on a wide range of food at different life stages and in different habitats. At various times and locations they feed on every level of the food chain.

Eel are carnivores and consume a variety of foods including demersal fishes and benthic invertebrates such as insects, crayfish, snails, and worms (Ogden 1970; Scott and Crossman 1973; Facey and LaBar 1981). Benthic organisms such as crayfish, various gastropods, and demersal fish are significantly more common in shallow littoral and stream habitats than in deep, cold water habitats. Godfrey (1957) concluded that about 10% of the eel examined had consumed whole fish, while 90% contained mostly insects. Facey and LaBar (1981) suggest that eel rely heavily on benthic organisms as evidenced by 43% of eel stomachs containing insects. Fish were found in 26% of the stomachs. Overall, smaller eel (43-57 cm) rely more on insects than larger eel (57 cm). In eight New Jersey streams, food size was also found to increase with eel size. Smaller eel fed on mayflies, megalopterans, and caddisflies (Smith 1985). Fish comprised at least 25% of the diet for approximately 20% of eel in New Jersey streams; bottom dwelling and sluggish species were most prevalent (Ogden 1970). Facey and LaBar (1981) indicated that the higher percent of fish in the diet of eel in Lake Champlain might have been due to the larger size of the eel in their samples (approximately 61-cm).

American eel leptocephali feeding habits have not been reported. However, the dentition and gape of the mouth suggest that they are capable of feeding on individual zooplankton and phytoplankton. Elvers collected from Cooper River, South Carolina, ate mostly larval and adult chironomids, cladocerans, amphipods, and fish parts (McCord 1977). More types of food were eaten by intermediate-sized yellow eel than by elvers or maturing yellow eel (Wenner and Musick 1975). Fish occur in the diet of intermediate-sized yellow eel during the winter and spring, while insects and mollusks were eaten from spring through fall (Wenner and Musick 1975). Yellow eel shorter than 40 cm in New Jersey streams mainly ate aquatic insects, whereas larger eel fed mostly on fish and crustaceans (Ogden 1970). Yellow eel in the lower Chesapeake Bay fed on crustaceans including blue crab (*Callinectes sapidus*), bivalves such as soft-shelled clams (*Mya arenaria*) and polychaetes (Wenner and Musick 1975). Eel have been considered to be significant predators on young salmonids, but this is not well supported in the literature (Facey and Van Den Avyle 1987; Godfrey 1957). Bigelow and Schroeder (1953) describe the American eel as feeding on whatever prey/food items happen to be found in its habitat. Given their poor eyesight and nocturnal feeding habits, yellow eel probably rely on their keen sense of smell to locate food (Fahay 1978). A diel foraging study in the Pettaquamscutt River estuary of Rhode Island showed that the foraging activity of estuarine eel was primarily nocturnal in late summer through autumn. The study also identified a peak of activity at nightfall, with most of their captures in traps occurring one hour after sunset (Sorensen et al. 1986). Yellow eel swallow some types of prey whole, but also can tear pieces from large dead fish, crabs and other items (Facey and Van Den Avyle 1987). Eel have been reported to accomplish this tearing off by biting and spinning rapidly (Helfman and Clark 1986).

1.2.5 Stock Assessment Summary

Historical Overview

The American eel has been an important food for native Americans since the pre-colonial era (Crawford 1996). Because eel are also present in European waters, this resource was well known to, and used by, the earliest European settlers to the North American continent. The first systematic records of eel harvests in Maine were collected in 1887 and harvests have been recorded more or less continuously since 1989. Atkins (1887) reported on the early Maine eel fisheries as follows: "Eel are taken with spears, in traps and pots set for the most part in tidal waters, and in weirs built across the streams that they descend in the autumn." Throughout the first half of the 20th century, the eel fishery was small (Crawford 1996).

European eel species and Asian eel species fisheries had declined by the late 1960s and their markets were in need of an external source (Crawford 1996). American eel that were exported from southern New England filled that need. The American commercial fishery has traditionally supplied American eel for the regional and the European food market, domestic trotline bait, and small bait eel for domestic sport fisheries. Glass eel and elvers are cultured to marketable size in Asia. When the Asian domestic stocks are inadequate, a strong market develops for American glass eel and elvers. The Asian market for American glass eel and elvers was strong from 1972-1977, declined dramatically in 1978, and began to strengthen in the 1990's.

Current Status

The current status of the American eel stock is poorly understood. This is due to limited and non-uniform stock assessment efforts and protocols across the range of this species. Reliable indices of abundance of this species are scarce. Limited data from indirect measurements (harvest by various gear types and locations) and localized direct stock assessment information are currently collected.

Although eel have been continuously harvested, consistent data on harvest are often not available. Harvest data is often a poor indicator of abundance, because harvest is dependent on demand and may consist of annually changing mixes of year classes. Most of the data collections were of short duration and were not standardized between management agencies. Harvest data from the Atlantic coastal states (Maine to Florida), indicate that the harvest has declined after a peak in the mid-1970s (Figure 3). Annual eel catch ranged from 885,267 lbs. to

3,608,357 lbs. between 1970 and 1998, but the catches averaged 2,540,599 lbs. between 1970 and 1984, and 1,356,434 lbs. between 1985 and 1998. The lowest harvest (between 1970 and 1998) was 885,267 lbs., which occurred in 1998. Because fishing effort data is unavailable, however, finding a correlation between population numbers and landings data is problematic.

In addition to commercial harvest, there are a few long-term data sets from fish ladders, impingement sampling, research collections, and monitoring programs. In 1974, Ontario Hydro and OMNR constructed the largest eel ladder in the world at the Moses-Saunders Hydroelectric Dam (Eckersley 1981; OMNR 1986). Eel count data from the ladder indicate there has been a significant and dramatic decrease in the number of eel ascending the ladder since the mid-1980's (Figure 4) (Casselman et al. 1997). However, this decline in eel counts may be an artifact of lock/water flow usage at the Beauharnois Dam which is downstream from the Moses-Saunders facility. Long-term data from the Conowingo Dam fish lift in Maryland, on the Susquehanna River, show a decline in elver counts from 1974 through 1996 (Figure 5).

Richkus and Whalen (1999) performed a trend analysis on eel migration data from 1984 to 1995, including data from the Moses-Saunders eel ladder (Table 1). Their results indicate significant negative trends for yellow and/or silver eel abundance in Ontario, Quebec, New York, and Virginia, although silver eel declines in the St. Lawrence River basin may be due to escapement reductions from upper St. Lawrence dams and water flow control rather than fisheries. The authors found no trends for glass eel or elvers, but those data sets were generally not complete and may not have covered the years where the largest declines were observed in other data sets (Richkus and Whalen 1999).

Richkus and Whalen's (1999) results support observations and concerns made by the state and federal fishery resource agencies, conservation organizations, and fisheries interests that the eel resource has been declining in abundance. As stated in the Goals of this Plan (Section 2.1) the purpose of this management effort is to reverse any local or regional declines in abundance and institute consistent fishery-independent and dependent monitoring programs throughout the management unit.

Recent Changes in Harvest

Domestic and overseas markets utilize American eel from most life stages. Most harvest data show a decreased recruitment and catch of glass, yellow and silver eel. Data on European eel also show a considerable decline in abundance since the late 1970's (Moriarty and Dekker 1997).

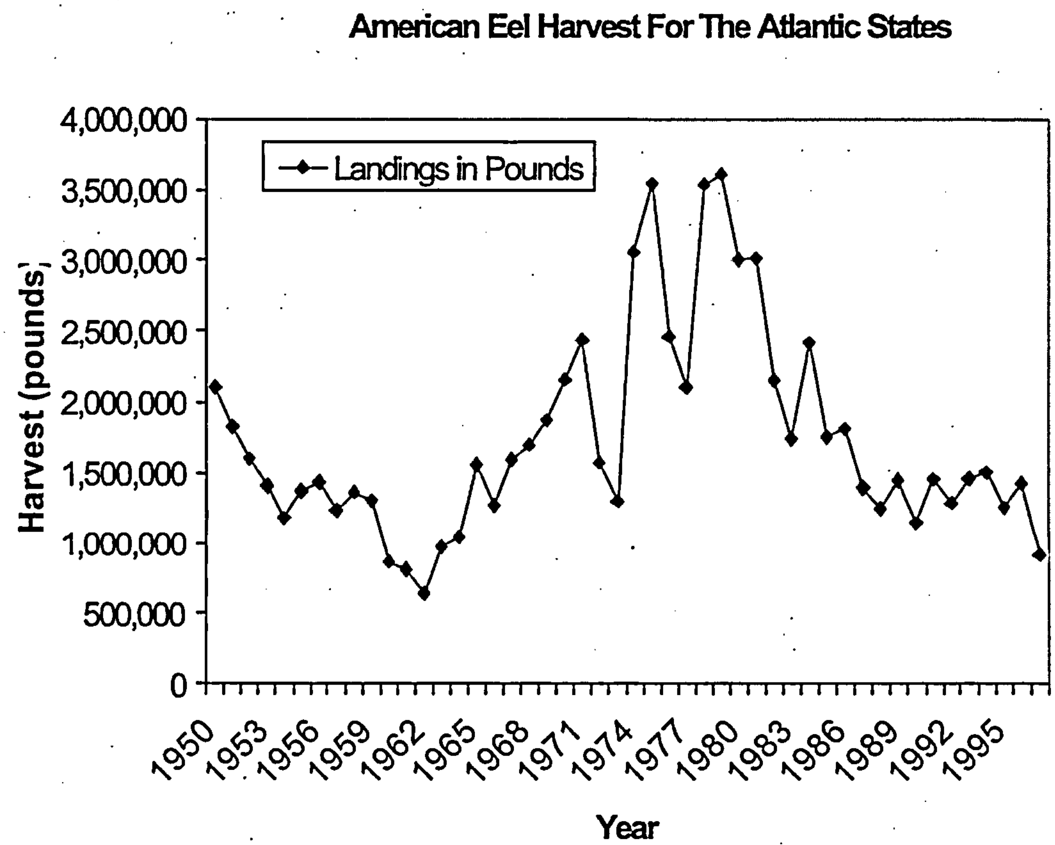


Figure 3. Annual harvest as reported by the Atlantic States from 1950 to 1998 (NMFS, Fishery Statistics and Economics Division, 11-15-99, pers. comm.).

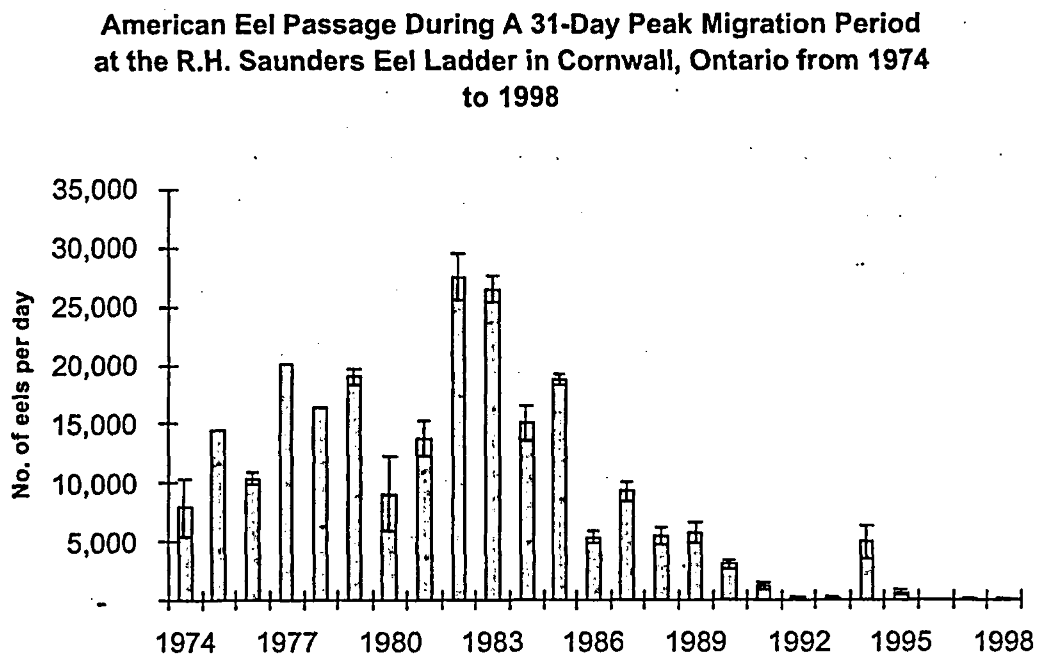
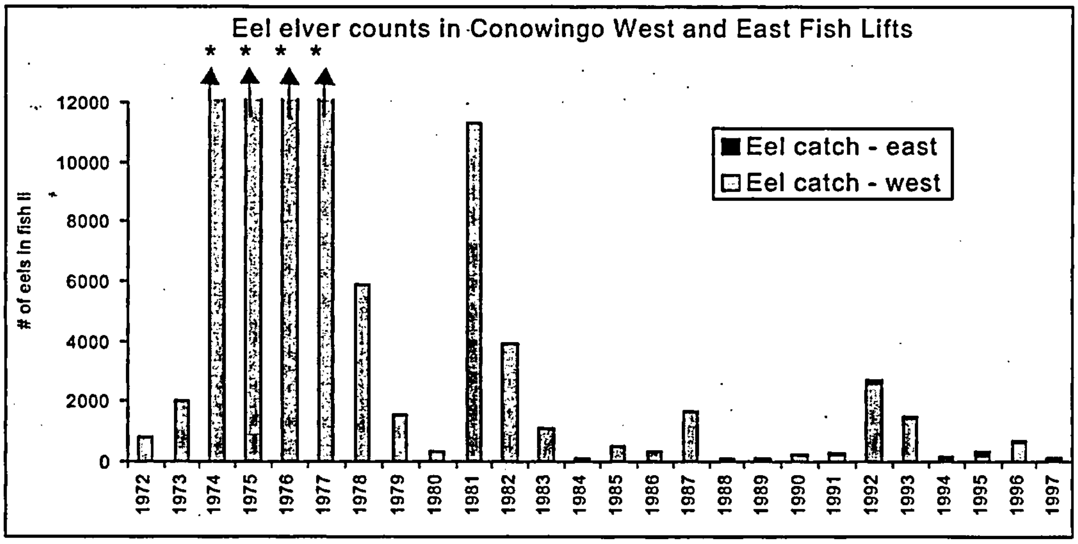


Figure 4. Mean number of eel ascending the eel ladder per day at the Moses-Saunders Hydroelectric Dam at Cornwall, Ontario, during a 31-d peak migration period from 1974-98. Vertical bars indicate the 95% confidence intervals (from Casselman et al. 1997, Mathers et al 1998).



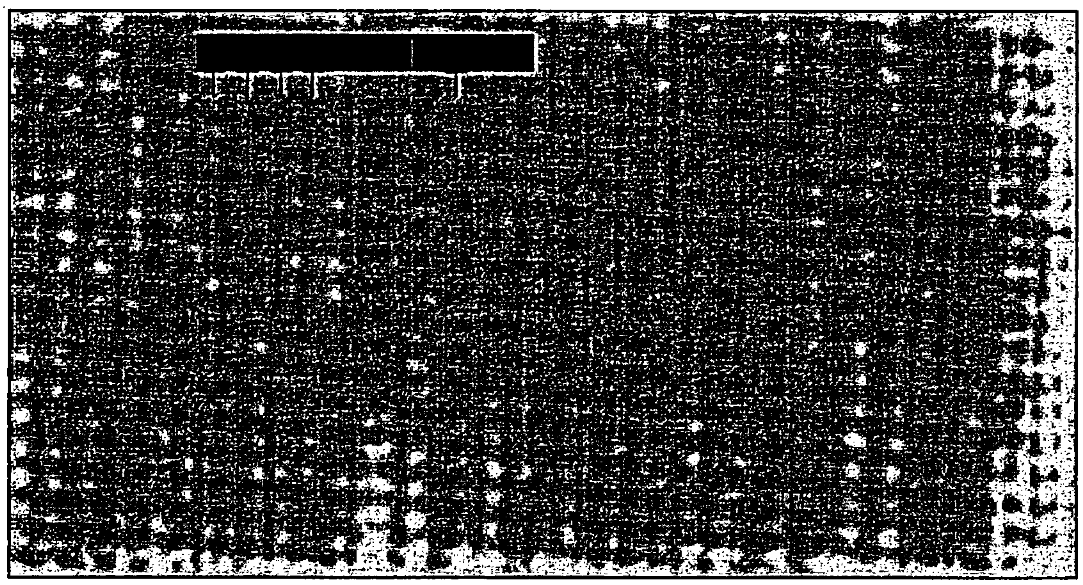


Figure 5. Data from Conowingo Dam fish lift, Susquehanna River, 1972-1997.

***Counts of eel in fish lifts for 1974, 1975 and 1976 were 126,543, 64,375, and 60,409 respectively (J. Weeder, MD DNR person. comm.). * Counts of fish per operating hour for 1974, 1975, 1976, 1977, and 1981 were 183.87, 209.69, 161.09, 35.35, and 41.20 respectively (J. Weeder, MD DNR person. comm.).**

Table 1. Summary of data sources used in Mann-Kendall trend analysis of eel abundance time series. Significance was determined at $\alpha = 0.05$; NS = not significant. Table is arranged approximately north to south. (Richkus and Whalen 1999)

State/ Province	Location	Available Years	Collection Method	Eel Life Stage	Mann-Kendall Trend Analysis (1984-95)
Nova Scotia	East River, Sheet Harbor	1990-97	Irish elver trap	Elver	NS
Ontario	St. Lawrence River	1974-95	Fish Ladder	Yellow eel	Negative $P < 0.001$
Ontario	Lake Ontario	1984-96	Commercial electrofishing	Yellow eel	Negative $P < 0.01$
Quebec	St. Lawrence River (lower)	1979-95	Weir trapping	Silver / Yellow eel	Negative $P < 0.01$
New Hampshire	Statewide	1988, 1990-97	Commercial eel pot	Yellow eel	NS
New York	Hudson River	1985-1995	Beach Seine Survey	Yellow eel	Negative $P < 0.1$
New York	Hudson River	1985-1995	Fall shoal survey	Yellow eel	NS
New York	Hudson River, Roseton	1973-96	Impingement sampling	Silver / Yellow eel	NS
New York	Hudson River, Danskammer	1974-96	Impingement sampling	Silver / Yellow eel	Negative $P < 0.001$
New Jersey	Little Sheepshead Creek	1989-94	Bridge netting	Glass eel	NS
PRFC	Potomac River	1988-97	Commercial eel pot	Yellow eel	NS
Virginia	North Anna River	1981-97	Electrofishing/ electroseining	Yellow eel	Negative $P < 0.01$
Virginia	VIMS trawl survey; rivers and estuaries	1954-96	Trawl sampling	< 180 mm (elvers/glass eels)	NS
Virginia	VIMS trawl survey; rivers and estuaries	1954-96	Trawl sampling	181 – 350 mm	NS
Virginia	VIMS trawl survey; rivers and estuaries	1954-96	Trawl sampling	< 350 mm (silver eel)	Negative $P < 0.05$
Virginia	VIMS trawl survey; rivers and estuaries	1954-96	Trawl sampling	All ages combined	NS

From the above data, it is apparent that overall eel harvest has declined. In addition, eel abundance in upstream migration has declined in the St. Lawrence (Casselman et al. 1997) and Susquehanna River Systems. Richkus and Whalen (1999) concluded that the trend analysis shows broad-based evidence for a stock-wide abundance decline of American eel from 1984 to 1995.

1.3 DESCRIPTION OF THE FISHERY

1.3.1 Commercial Fishery

Jessop (1997) provides a brief but highly concise summary of the status of the American eel fishery along the Atlantic seaboard of the United States. It is presented below with a few updates concerning Pennsylvania and New Jersey.

Glass eel/Elver Fishery

Interest in fishing for American elvers and glass eels, primarily for export to Asia for aquaculture, developed in **Florida, North** and **South Carolina, Virginia, Massachusetts** and **Maine** during the early 1970s (Fahay 1978; Keefe 1982; Mullis 1982). Elver/glass eel fisheries failed to develop in Florida, ceased in 1977 in North Carolina and probably also in South Carolina, and were prohibited in 1977 by a 15 cm minimum size limit in Virginia and a 10 cm minimum size limit in Massachusetts (CBP 1991). The **Potomac River Fisheries Commission** imposed a 6-inch minimum size effective January 1, 1992, applying to both commercial and recreational fisheries, therefore eliminating any glass eel/elver fishery. Reported catches in Maine were 10 t in 1977 and 7.6 t in 1978 (Dow 1982) but catch statistics are unavailable for the other states. The Maine elver/glass eel fishery collapsed after 1978 due to market conditions, but continued at a low level until growing substantially in 1994. Reported catches of 3.3 t occurred in 1994, 7.5 t in 1995, and 4.6 t in 1996 (CAEMM 1996; L. Flagg, Maine Department of Marine Resources, pers.comm.). With the exception of 1977 and 1978, elver/glass eel catches in Maine cannot be separated from yellow/silver eel catches prior to 1994 when specific records of elver/glass eel catches were initiated. During the late 1980s or early 1990s, elver/glass eel fisheries were developed or reestablished in **Connecticut, Rhode Island, New York, New Jersey, Delaware** and **South Carolina** but no catch data are available. Elver/glass eel fisheries do not occur in any **Gulf of Mexico** states.

The recent surge of interest in fishing for elvers/glass eels and the sometimes-chaotic nature of the fishery has evidently caught state fishery managers unprepared. Few states, which presently permit elver/glass eel fisheries (Maine, Connecticut, South Carolina, and Florida), have comprehensive regulations for those fisheries. Although 11of 15 Atlantic coastal states presently ban elver/glass eel fisheries, several states prohibited the elver/glass eel fishery only recently in response to a perception of uncontrolled development. Permits to fish elvers/glass eels may specify various conditions, such as quota, area to fish (all are restricted to tidal waters), gear types, season, etc.

Maine leads other elver/glass eel fishery states in modernizing its elver/eel fishery regulations. It has recently proposed and/or implemented regulatory changes to increase elver/large eel license fees to $200.00 in an effort to dedicate license fee revenues to eel research and provide enforcement for the fishery. Maine has imposed a March 15-June 15 fishing season and two day weekly closed time for elvers/glass eels (defined as eel less than 15 cm long). It will also limit the number, type, and methods of operation of gear units available to each fisher in an attempt to control fishing effort, limit elver/glass eel fishing to the intertidal area and the shoreward one-third of a stream (both shores), and prohibit both elver/glass eel fishing within 46 m of any dam and bycatch of other species (CAEMM 1996).

The **Connecticut** regulations were minimal until 1996, e.g., no small mesh fyke nets, but pots and dipping are permitted; catch reporting requirements permit minimal interpretation of catches. In 1996, Connecticut defined the glass eel as less than 10 cm in length, instituted a March 1-May 31 glass eel fishing season with a weekly closed period from 6:00 pm Saturday to 6:00 am Sunday, prohibited obstruction of more than 50% of the stream width and placement of traps within 7.6 m of each other, limited traps to a maximum of 10 within the state and 3 in any stream (dipnets are the preferred fishing gear) and required monthly catch reporting by logbook. The elver/glass eel fishery in **New Jersey** was unregulated prior to 1997 when it was restricted to dip-nets only and a fishery season was implemented (February 15-April 20) with a Sunday closure. The elver/glass eel fishery has been closed since 1998. (ASMFC 1997; J. F. McClain, New Jersey Division of Fish, Game and Wildlife, pers. comm.).

At various periods between 1957 and 1980, elvers (range 23,000 to 6,000,000 elvers) were annually stocked in the Susquehanna River, **Pennsylvania** upriver of hydroelectric dams, but no commercial eel fishery is permitted, and personal use harvesters are restricted to 50 eel per person per day.

Virginia issued, in 1996, two permits to fish a total of about 800 kg of elvers/glass eels for local aquaculture; no additional permits are planned for several years. When the cultured elvers have been reared to sale size, 10% must be returned to the state for release in the wild. **South Carolina** has an active elver/glass eel fishery. A limited fishery exists for elvers in Florida, and one experimental permit has been issued for harvesting glass eel.

The number of elver/glass eel fishers is generally unregulated in those states where an elver/glass eel fishery occurs (excluding **Virginia** where two permits exist, and **Florida** where the glass eel/elver fishery has been under limited regulation and three special device permits exist). In **Maine**, the number of commercial finfish permits (which may be used to fish eel as well as other species) almost tripled between 1985 and 1995 and more than doubled between 1994 and 1995 to over 3,300 permits, of which over 1,500 are believed to be elver/glass eel fishers (CAEMM 1996). As of the 1999 fishing season, Maine representatives claim that permits have been reduced by two-thirds of the 1994-1995 reports (J. Goldthwait Person. Comm.). **Connecticut** has had a moratorium on new commercial fishing licenses since 1995 but existing licensees can fish elver/glass eel if they choose. In **New Jersey**, over 2,100 licenses were issued for the 1997 elver/glass eel dip-net fishery (J. McClain, New Jersey Division of Fish, Game and Wildlife, pers. comm.). **South Carolina** had no mechanism for determining participation in the elver/glass eel fishery in coastal waters until 1996 when a permit was instituted (B. McCord, South Carolina Department of Natural Resources, pers. comm.). In 1997, about 65 permits for elver/glass eel hoop nets (a type of fyke net) and 11 permits for dip nets were issued. Each permit may authorize one or more units of gear.

Some states (**Connecticut, South Carolina,** and **Florida**) have no minimum length limit for eel retention (Table 2). **Maine** has a 6 in minimum size limit except during the elver season, which runs from March 15 through June 15. **New Hampshire** has a 10 cm minimum size limit as does **Massachusetts**, except for aquaculture (Amaral 1982). A 15 cm minimum size limit was imposed in **Virginia** in 1977 (CBP 1991) and has existed in **Georgia** since at least the early 1980s (J. Music, Georgia Department of Natural Resources, pers. comm.). **New York, Rhode Island, Delaware, Maryland, PRFC** and **North Carolina** have only recently (1992-1995) imposed a minimum length limit of 15 cm so as to protect elvers/glass eels for local aquaculture development or, more urgently, to prevent uncontrolled development of an elver/glass eel fishery. These states await the recommendations on elver/glass eel fishery development expected in the ASMFC fishery management plan for eel. In 1994, Maryland permitted a daily harvest per person of up to 25 eel of less than 15 cm for use as bait, primarily by anglers.

Maine has a defined elver/glass eel fishing season (March 15 to June 15). No states with an elver/glass eel fishery, other than Maine, have begun collection of catch statistics although this is expected to change when the ASMFC fishery management plan for eel is implemented. Poaching of elvers/glass eel is believed a serious problem in many states but enforcement of the often minimal regulations is poor due to the nature of the fishery (very mobile, nighttime operation) and low administrative priority.

Table 2. Commercial eel fishing regulations summary [1].

State/ Province	Minimum Length	Pot Mesh Size[2]	Freshwater Fyke	Weirs	License	Comments
Newfoundland	8"		2"/3" Stretch	No	No Data	
Prince Edward Island	18.4"		No	No	No Data	
Nova Scotia	8"		No	No	$10	
New Brunswick	8"		No	No	$10	
Maine	None (3/15-6/15) 6" (6/16-3/14)	½" x ½"	Yes	Yes	$33 + Gear Fee For Glass Eel For Residents $334 + Gear Fee For Glass Eel For Nonresidents $100 Weir/Pot	$75 For Dip Net. $100 Each For First Two Fyke Nets, $200 Each Next Three, Limit Five, For Glass Eel
New Hampshire	6"	Yes	No	No	$26 Resident $200+ Nonresident	Coastal Netting License Required For Nets & Pots
Massachusetts	4"		No	No	$65 Resident-Saltw. $130 Nonresident-Saltw.	Freshwater $25 plus state sports license $27.50
Vermont						
Rhode Island	6"		No	No	$200	
Connecticut	None	No	No	No	$50 Resident $100 Nonresident	Dip Net Glass Eel. 3/1-5/31 glass eel season with weekly closed periods. License Moratorium.
New York – Marine	6"	1" X ½"			$250 Resident $1250 Nonresident	License Moratorium
New York – Inland	None	No Opening Not > 2" Dia	Yes	Yes	$20 Resident $60 Nonresident	
Pennsylvania	6"					Ban on commercial eel fishing
New Jersey	6"	4/16" Bar	No	No	$10 Bait Net Resident $100 Bait Net Nonresident $100 Min. Fyke/Pot Residents $1000 Min. Fyke/Pot Nres.	Glass eel/elver fishery closed
Delaware	6"	No	No	No	$115 Resident $1150 Nonresident	
Maryland	6"	½" x ½" or escape panel	No	No	$300 Resident, tidal $350+ Nonresident, based on home state $100 unlimited finfish harvester	Limited entry
PRFC	6"	½" x ½"	No	No	$75 Per Boat	
District of Columbia						No Commercial Fishing
Virginia	6"	½" x ½" with 4" x 4" escape panels	No	No	$150 + Gear Fee	2 Year Wait
West Virginia	None				Resident + Conservation Stamp	Except 5/15-6/30. Gigging, Snagging, Snaring Are Prohibited
North Carolina	6"	1" x ½"	No	No	$10 Resident $50 Non-resident	20 Eel Limit Per Person Per Day
South Carolina	None	½" x ½"	Yes	No	$50 Resident $1000 Nonresident	Dip nets licensed, gear permit also required in addition to licenses
Georgia	6"	1½" x ½"	No	No	$12 Resident $118 Nonresident	
Florida	None	1" x ½"	No	No	$25 Resident $100 Nonresident	

[1] Regs subject to change: contact state for current requirements. [2] Escape panels of varying sizes by state required.

Yellow/Silver Eel

The United States fishery for American eel extends from Maine to the Gulf of Mexico. Different geographic regions (north, middle, and south Atlantic, Gulf of Mexico) exhibit differing trends and magnitudes in their eel fisheries, which reflect differences in their fisheries and stock abundances (Fahay 1978). The 1955-1973 fishery was most productive in the middle Atlantic region (New Jersey to Virginia), followed by the north Atlantic region (Maine to New York), south Atlantic region (North Carolina to Florida), and Gulf region where the catch was negligible (Fahay 1978). The regional catch summary statistics reported by Fahay (1978) are slightly lower than statistics recently available from the National Marine Fisheries Service (NMFS 1997), but the regional rankings are unchanged. For the years 1955-1973, regional mean catches were 146 t (range 75-251 t) for the north Atlantic region, 429 t (range 152-930 t) from the middle Atlantic region, and 80 t (range 19-192 t) from the south Atlantic region. For the years 1974-1995, regional mean catches increased to 160 t (range 7-556 t) in the north Atlantic region, to 567 t (range 106-1,349 t) in the middle Atlantic region, and to 236 t (range 6-792 t) in the south Atlantic region. The higher regional mean catch in the 1974-1995 period is accompanied by higher annual variability, reflecting the declining catch in all regions (and most states) from peaks in the mid-1970s and early 1980s to the low values of recent years.

For the Atlantic coast (Maine-Florida), annual eel catch ranged from 384 t to 1,645 t between 1970 and 1995, with values between 1.17 and 5.49 million U.S. dollars (ASMFC 1997). Eel catches averaged 1,179 t between 1970 and 1982 and 635 t between 1983 and 1995, indicating an overall decline in US catch.

Annual trends in reported eel catches by individual states (NMFS Fishery Statistics and Economcis Department pers. comm.) comprise three basic groups: declining catch, e.g., Rhode Island, New York; increasing catch, e.g., New Jersey, Delaware, Maryland; and catches that have returned to values typical of those reported prior to the peak catches of the 1970s and early 1980s, e.g., Maine, Massachusetts, Florida (Figure 6). Reported catches in some states declined sharply in 1996 but catch data may be incomplete.

Maine eel catches peaked in the late 1970s at 50-90 t annually and have since fluctuated between 4 t and 30 t, a level only slightly lower than reported between the early 1950s and early 1970s. In **Rhode Island**, eel catches varied moderately from about 9 t to 30 t between 1962 and 1984, then increased to between 19 t and 56 t between 1985 and 1988 before collapsing to about 1 t during 1989 and 1990 (Gray 1991). The catches reported by Gray (1991) during the mid-1980s are not evident in Figure 6 yet both data sets originate from the National Marine Fisheries Service. The variability in Rhode Island eel catch during the 1980s has been attributed to market forces rather than resource status.

Annual reported eel catches in **Connecticut** have usually been less than 10 t since about 1980 but some fishers blame the recent low catches on overharvesting of elvers/glass eels (NMFS 1997; S. Gephard, Connecticut Department of Environmental Protection, pers. comm.). Eel fisheries in inland (primarily Lake Ontario and Hudson River) waters of **New York** state have been closed due to organochloride contamination since 1976, with the exception of a "limited" fishery for export that closed in 1982 (Blake 1982; Lary and Busch 1997). Historically, catches of eel in New York were several times higher in coastal waters (1960-1978 mean catch of 68 t) than in inland waters (1960-1979 mean catch of 18 t). The export fishery evidently generated high catches in inland (mean 36 t) and coastal waters during the years 1980-1982 (Lary and Busch 1997).

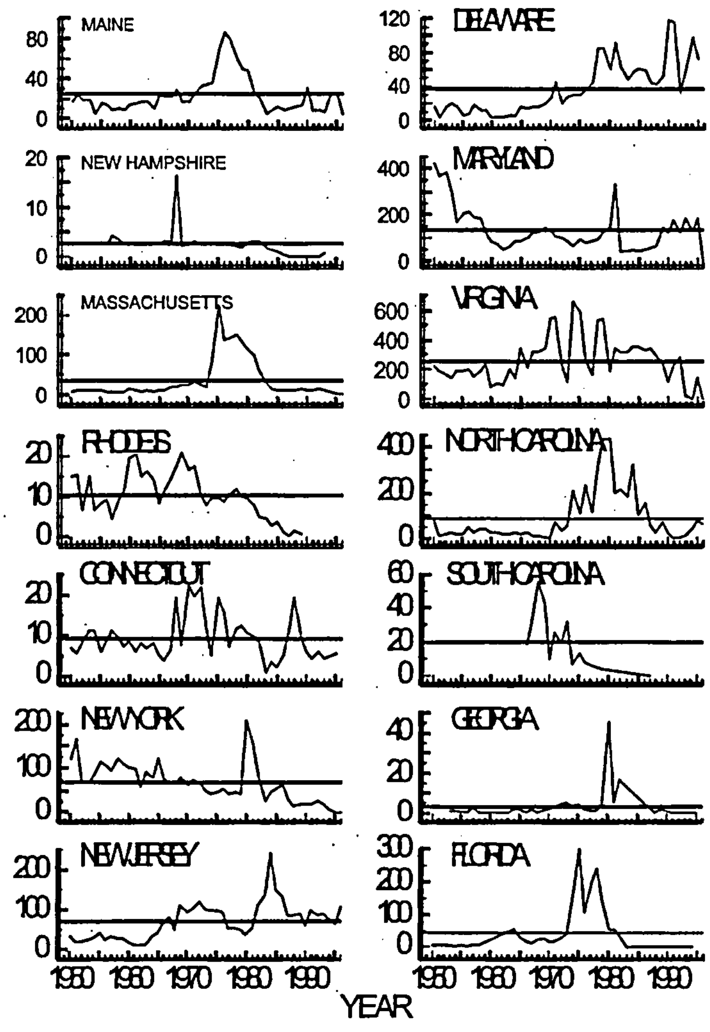


Figure 6. Annual reported (NMFS) catches of American eel, by state, for the Atlantic coast, 1956-96. The vertical line in each graph is the mean catch. Source: Jessop (1997).

In New Jersey, eel catches in the primarily coastal pot fishery ranged from 61-98 t between 1989 and 1993, down from the mid-1980s peak of 134 t but near the long-term mean. **Pennsylvania** issued 1 or 2 weir/chute licenses for use on the Delaware River. In 1997, the sole operator reported a harvest of less than one ton. No operations were conducted in 1998. The new regulations (no commercial sale, 50 fish daily limit, etc.) are expected to result in little, if any, interest in eel weir/chute operations.

In Chesapeake Bay (Maryland and Virginia) recent catches are near the long term (1945-1994) mean of about 450 t (CBP 1995). In **Maryland**, reported eel catches steadily declined from the peak of about 590 t in 1946 to about 45 t in 1963 and have since fluctuated between 45 t and 100 t (CBP 1995). The declining catch since the late 1980s evident in Figure 3 differs from the relatively stable catch reported elsewhere (CBP 1995). Reported catches in **Virginia** fluctuated between about 80 t and 190 t between 1946 and 1966, then increased irregularly to a peak of 659 t in 1974, before declining to 149 t in 1993 and rising to 360 t in 1994 (CBP 1995). Between 1984 and 1994, reported catches averaged 91 t (range 11-134 t) in Maryland (annual catch per fisherman increased from 0.9 to 2.0 t; CBP 1995) and 376 t (range 270-510 t) in Virginia (CBP 1995; Speir 1996). Reported catches in Maryland have thus shown no particular trend since about 1960 while Virginia catches remain near the long-term mean despite the decline from the 1974 peak.

Catches in **North Carolina** and **Georgia** have declined from the peaks in the early 1980s to levels not seen since the 1960s and early 1970s. Before 1970, annual eel catches in North Carolina were usually less than 45 t, then peaked at 436 t in 1980 (Keefe 1982) before declining to 6-26 t in the 1990s. The mean annual catch of the minor fishery in Georgia declined from 8.5 t between 1972 and 1982 to 1.6 t between 1983 and 1995 (J. Califf, Georgia Department of Natural Resources, Brunswick, pers. comm.). Although catches of over 100 t were reported from **Florida** during the mid and late 1970s, the only significant eel fishery in Florida today is the pot fishery of the Saint Johns River. Recently, catches in this fishery have declined, due in part to reduced fishing effort (NMFS 1997; J. Crumpton, Florida Game and Freshwater Fishery Commission, Eustis pers.comm.). Reports indicate that the maximum number of fishers involved in the Florida eel fishery has never exceeded 50 participants (J. Crumpton, Florida Game and Freshwater Fishery Commission, Eustis pers.comm.). Currently, there are 25 – 30 fishers involved in the fishery and participation has been stable since the mid 1980s.

Drawing conclusions from these trends is difficult because the available catch statistics are generally regarded as underestimates, perhaps varying in completeness over time, and fishing effort data are either unavailable or of questionable utility (Foster 1981; CBP 1991; Crawford 1996; NMFS 1997). The current status of the eel stock in most, if not all, states is unknown due to the absence of catch and/or effort statistics and an absence or scarcity of biological study of any kind. A widespread concern about the status of local eel stocks, except perhaps in Pennsylvania, Georgia, Florida, and the Gulf of Mexico where stocks and fisheries are not usually as large as in other areas, reflects more the absence of knowledge about the stocks rather than a well-founded knowledge of decline.

The economically important yellow/silver eel fishery in **Maine** occurs in both inland and tidal waters. The fishery is comparatively well documented and has recently received a comprehensive review and modernization of regulations (CAEMM 1996). Most large eel fisheries south of Maine seem to be primarily coastal pot fisheries with little management and few regulations, other than a license requirement and perhaps minimum size limit or gear and mesh size restrictions (Table 2). Eel fisheries are conducted during the period of natural availability, and few, if any, states have defined fishing seasons. **New Hampshire** has little coastline and no available data on eel fishing. Coastal town authorities (little if any eel fishing occurs inland) manage the coastal eel fisheries of Massachusetts; state regulations control permitted gear types (Amaral 1982). The tidal water, mainly pot fishery conducted between May and November in **Rhode Island** requires a commercial multispecies marine fishing license but no catch statistics are collected by state agencies for the eel fishery (Gray 1991). **Connecticut** has a relatively small, basically unmanaged, pot fishery for yellow eel in the tidal portions of, primarily, the Connecticut and Housatonic rivers (S. Gephard, Connecticut Dept. of Environmental Conservation, pers.comm.).

Table 3. Commercial landings and value of American eel in the State of Maine.

Year	Landings, pounds	Value	Average Price per Pound
1994	64,135	$85,473	$1.52
1993	14,521	28,022	1.93
1992	30,672	55,823	1.82
1991	18,217	27,331	1.50
1990	66,164	86,320	1.30
1989	27,900	29,247	1.05
1988	----[1]		
1987	13,288	13,700	1.03
1986	16,703	13,219	0.79
1985	24,100	18,288	0.76
1984	8,764	6,610	0.75
1983	11,900	8,925	0.75
1982	45,051	36,637	0.81
1981	55,125	45,308	0.82
1980	105,463	111,061	1.05
1979	111,206	89,214	0.80
1978	133,388	161,892	1.21
1977	175,711	262,596	1.49
1976	191,025	93,665	0.49
1975	154,836	82,380	0.53
1974	79,524	32,318	0.41
1973	79,890	29,555	0.39
1972	70,210	24,578	0.35
1971	54,300	15,204	0.28

[1] No data on landings collected in 1988

Licensed eel fishing in **New York** occurred, primarily in Lake Ontario, the Hudson River (prior to the 1976 closure), and the upper Delaware River (Blake 1982). Only eel less than 36 cm may be fished in the Hudson River proper and other inland waters and must be used for bait because of organochloride contamination. Coastal fisheries are unlicensed and fishing effort is not monitored in either inland or coastal waters. New York enacted, in 1995, a 15-cm minimum size limit and 1.25 x 2.5-cm minimum mesh size for trap nets in marine waters. **New Jersey** fishery regulations require a fishing license for fyke nets and pots, a minimum 4.8-mm bar mesh in pots and a 15-cm minimum size limit. Eel fisheries in **Delaware** were recently licensed and had a 15 cm minimum length limit set in 1995 but are otherwise unregulated and thus have no available catch data.

Maryland and **Virginia** primarily operate pot fisheries for eel in Chesapeake Bay, for which a management plan was developed in 1991 (CBP 1991, 1995; Speir 1996). Prior to the 1991 management plan, **Pennsylvania, Maryland,** and **Virginia** had no harvest quotas (**Pennsylvania** has a 50 eel per person per day creel limit), bycatch restrictions or closed season nor do they exist under the management plan. Prior to the 1991 management plan, Virginia had a 1.25 x 1.25-cm minimum mesh size and requirement for two 1.25 x 2.5-cm escape panels for eel pots. Maryland has implemented a similar minimum mesh size under the management plan. Large eel are exported whereas small eel are used for bait in the crab trotline fishery. Such use is of declining importance. Catch reports were not required in Virginia prior to 1973 and the Maryland eel fishery was unlicensed prior to 1981. Furthermore, Maryland did not require reporting of eel catches until 1990 (Foster 1981; CBP 1995; Speir 1996). The National Marine Fisheries Service made estimates of commercial eel landings based on interviews with fishhouse managers for both states from 1929 onward (CBP 1995).

North Carolina has a small, primarily coastal pot fishery, with no catch records maintained for inland waters, although they may be included in the total catch. **South Carolina** recently instituted a permitting system to document total eel gear and commercial harvest (B. McCord, South Carolina Department of Natural Resources, pers.comm.). Traps, pots, fyke nets, and dip nets are permitted in coastal waters. Fishing for eel in coastal waters is often conducted under the guise of fishing for crabs.

Eel fishing in **Georgia** was restricted to coastal waters prior to 1980 when inland fishing was permitted (Helfman 1982). Catch, but not effort, data is available because no specific license is required to fish eel. The **Florida** pot fishery has a 1.25 x 2.5-cm minimum mesh size and no minimum catch size limit, although frequency data indicates that the minimum size harvested by Florida pots is approximately 12 inches (J. Crumpton, Florida Game and Freshwater Fish Commission, Eustis pers. comm.).

1.3.2. Glass Eel Fishery

Maine landings of glass eel have been recorded separately from landings of adult eel since 1994. The elver/glass eel landings and value for 1994 and 1995 (DMR and DIFW 1996) were:

Year	Pounds landed	Value ($)	Average Price ($) per Pound
1994	7,347	367,350	50
1995	16,599	3,821,842	230

1.3.3 Bait Fishery

The information available from NMFS concerning eel harvested for bait indicate a decrease in pounds harvested. However, during this period average eel weight ranged from 0.25 to more than 1 pound. While the data needs to also be adjusted for numbers, it is arguable that this trend would remain apparent in light of such adjustments. In addition, recreational bait harvest is not recorded.

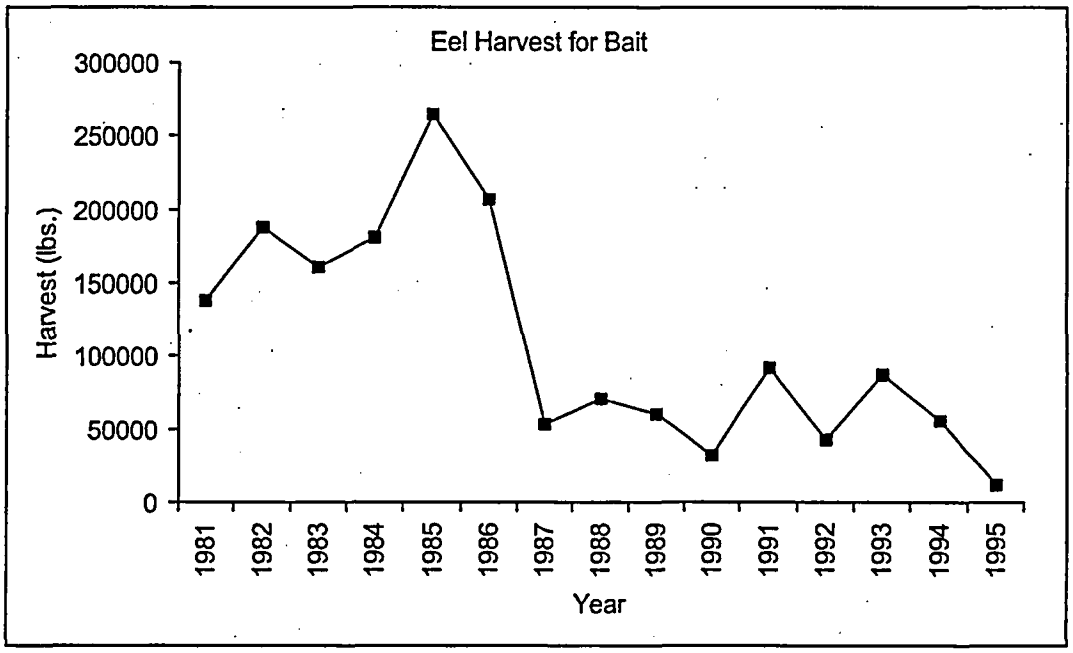


Figure 7. Harvest of American eel for bait (1981-1995) (NMFS)

1.3.4 Overall Commercial Fishery

1.3.4.1 Landings vs. Live Exports

Landings of American eel reported to the National Marine Fisheries Service (NMFS) were variable from 1970 to 1979 with lows in 1973 and 1977 of 592,091 kgs and 955,182 kgs and highs in 1975 and 1979 of 1,610,409 kgs and 1,648,607 kgs respectively. The trend shifted predominantly downward from 1979 to 1995 with a 76.7% decrease in kgs landed from 1979's high to a record low of 384,830 kgs in 1994.

Landings of American eel reported to NMFS were often far below the weight of eel exports reported by the U.S. Census Bureau. In 1993, a harvest of 400 tons of eel was reported to the NMFS but data from the Census Bureau indicate that 1,043 tons of live eel were exported, or 261% more than the reported harvest. Reported harvest decreased 45% during the three-year period from 1993 through 1995. By 1995, the difference in harvest reported to the NMFS or to the Census bureau had dropped to 3.6%.

1.3.4.2 Number and Value of Exports

The number of reported shipments of live American eel from 1992 to 1995 rose 153%, from a low of 240 to a high of 367. The number of reported shipments dropped again in 1996 to 308. The total value of American eel shipments rose dramatically during the time period. Values held relatively steady in 1992 and 1993 at around $4,600,000, but began to rise in 1994 to $6,967,019 and then increased in 1995 to $10,688,579. This represented a 230% increase from the 1992 low. The values dropped again in 1996 to $8,748,560, but remained 188% above 1992.

The mean value per shipment of American eel increased from 1993 to 1996, but showed a differential rate of increase dependent upon whether the shipment was destined for a European or Asian port. The mean value of a European bound shipment in 1993 was $14,184. The mean value for a similar shipment increased 65.0% in 1996 to a four year high of $23,438. The mean value of an Asian bound shipment in 1993 was $24,297. The mean value rose 59.9% in 1994 to $38,862 and continued to increase to a four year high of $42,707 in 1996, for a total 75.8% increase over the 1993 value. The difference in mean shipment value between shipments bound for European and Asian destinations increased from 1992 to 1996 with Asian shipments valued 72.3% more than European shipments in 1992 to an 82.2% higher value for Asian destinations in 1996.

During 1996 the number of live American eel export shipments showed a bimodal distribution with peaks in April and October of 63 and 34 shipments respectively. This contrasted with three shipments of 3 in January, 11 in August, and 8 in December. The total weight of those shipments showed a similar pattern ranging from 2,059 kgs in January to 122,321 kgs in April, dropping to 11,658 kgs in August, rising again to 78,102 kgs in October, and finally ending the year with 12,959 kgs in December. The value of live American eel shipments in 1996 likewise followed a bimodal pattern with peaks of $2,438,580 in April and $659,343 in October. The distribution of shipping patterns changed in both port of exportation and port of destination from 1993 to 1996. In both years New York handled the largest number of shipments with 135 in 1993 and 165 in 1996. Boston with 92 shipments and Washington, DC with 51 were second and third largest in 1993. However, by 1996 Maine border ports with shipments trucked to Canada tied for second largest number with Washington, DC at 46. Traffic at Boston dropped to only 13 shipments for 1996. In 1993, 280 shipments or 90.9% of total exportations of live American eel were destined for European ports while 28 or 9.1% were destined for Asian ports. Although the same number of shipments were exported in 1996 as in 1993 (308), the pattern of destination ports shifted so that 36.6% of shipments went to Asian ports, 47.4% to European ports, and 16.2% went to North American destinations.

Data for weight (kg) of American eel landed in the US for 1970 to 1995 were obtained from National Marine Fisheries Service (NMFS) (personal communication from the NMFS, Fisheries Statistics and Economics Division). Yearly export figures for live American eel shipments for 1993 through 1995 were obtained from U.S. Exports of Merchandise issued by the US Census Bureau (USCB). Monthly figures for live American eel exports for 1996 were obtained from individual monthly CD-ROMS for the U.S. Exports of Merchandise.

Information on American eel landings is collected by NMFS from the states of Connecticut, Delaware, Massachusetts, Maryland, Maine, North Carolina, New Jersey, New York, and Virginia. These data document landings from the majority of states with commercial American eel fisheries, but must be considered only a partial summary, as several other range states are not included.

Information in U.S. Exports of Merchandise is provided by shippers at the time of exportation via submission of a Shipper's Export Declaration (SED) to U.S. Customs Service (USCS). USCS forwards that information to the US Census Bureau for compilation and dissemination to the public. Shippers are required to furnish SED's for all export shipments valued in excess of $2,500, but this valuation level may mean that some small American eel shipments are not reported at the time of exportation.

There is a further caveat in the use of these data sets as neither differentiates among American eel life stages. In all likelihood, NMFS data consist almost exclusively of adult American eel as it is based on reported landings. USCB data is probably based on adult American eel shipments, but may include some portion of immature American eel, primarily the glass eel or elver stages.

1.3.5 Recreational fisheries

Few recreational anglers directly target eel. Eel, for the most part, are caught incidentally by hook and line fishermen when fishing for other species. The NMFS Marine Recreational Fisheries Statistics Survey (MRFSS), which has surveyed recreational catch in ocean and coastal county waters since 1981, shows a declining trend in the catch of eel during the latter part of the 1990's. From the Atlantic coast area surveyed, the estimated total annual catch of eel ranged from 212,690 eel per year in 1982 to 36,741 eel per year in 1997. About one half of the eel caught were released alive by the anglers. Eel are often purchased by recreational fishermen for use as bait for larger gamefish such as striped bass, and some recreational fishermen may catch eels and then utilize them as bait

1.3.6 Subsistence fisheries

Little is known as to the current extent (i.e., quantity) of subsistence fisheries for American eel. American eel are a valuable subsistence food source for some European and Asian ethnic groups, and , as noted earlier, represent an important food, cultural, and spiritual resource to many Native American tribes.

1.4 Habitat Considerations

1.4.1 Habitat Important to the Stocks

1.4.1.1 Description of Habitat

A habitat area of particular concern is defined, as those waters, substrate, and conditions required for population survival. Such habitat may be limiting for spawning, breeding, feeding, or growth to maturity.

Information inferred from commercial harvest records and various stock assessment efforts indicate that American eel are found in most types of habitats including the offshore, mid-water and bottom areas of lakes, estuaries and large streams. American eel are found to be most prevalent in the nearshore, shallow embayments and tributaries (Adams and Hankinson 1928, Facey and LaBar 1981, GLFC 1996, Helfman et al. 1983, NYSDEC 1997a & b).

American eel are classified as a warmwater species (Adams and Hankinson 1928) that are most abundant in relatively warm streams and shallow lakes or embayments (Ogden 1970), while relatively scarce in deep, steep gradient cold-water lakes (Smith and Saunders 1955). Based on distribution and diet preferences, American eel appear to be very adaptable creatures with the ability to exploit many habitat and food types. Some juvenile American eel, for example, seek out riverine habitat until reaching maturity at which time they return to the ocean. These habitats provide the conditions needed by the organisms (insects, crustaceans, fishes) that eel forage upon.

American eel are bottom dwellers while in estuaries, rivers, and lakes. The presence of soft, undisturbed bottom sediments may be important to migrating elvers for shelter (Facey and Van Den Avyle 1987). American eel have been reported in mud burrows with their heads protuding (Fahay 1978). Few other freshwater fishes display similar habitat use, and as a result, interspecific competition for living space may be limited (Facey and Van Den Avyle 1987). Estimates of the home range of eel extend to 3.4 ha in small streams, tidal rivers, and tidal creeks (Gunning and Shoop 1962, Bianchini et al. 1982, Bozeman et al. 1985) and 2.4 to 65.4 ha in a large lake (LaBar and Facey 1983).

Current research shows extensive use and home-range development of shallow lakes (< 17meters) by American Eel (Daniels 1999). Many riverine systems utilized by American eel in North America contain lakes and large bodies of water, but only the St. Lawrence basin includes the large inland Lake Ontario.This system is, therefore, the exception and raises doubt that the lake proper is the desired "end point " for the freshwater, inland migration of eel. While Lake Ontario may support a percentage of the stock at any one time, it is likely that the eel inherently continue to seek out riverine habitat in Lake Ontario tributaries, as they do in other East Coast streams. Lake Ontario is very limited in shallow habitats (due to its depth and narrow littoral area) and American eel must seek out their preferred forage in the habitat where it is abundant, such as in embayments and rivers where benthic invertebrate densities are found to be highest (Lary and Busch 1997).

Spawning Habitat

American eel are highly migratory, with spawning and larval development and migration occurring in the open ocean, feeding and growth occurring in estuaries and fresh waters, and migration of adults occurring in the ocean again to complete the life cycle [catadromous life cycle]. American eel spawn in the Sargasso Sea although it has never been directly observed in the field (Facey and Van Den Avyle 1987).

The Sargasso Sea is an oval area in the middle of the Atlantic Ocean, between the West Indies and the Azores, of nearly 5.2 million km^2 (2 million $miles^2$). Although the boundaries are not easily delineated, the area is identified as the "eye" of a large, slow, clockwise moving gyre of very clear, deep blue colored, warm surface waters, with elevated salinity. The Gulf Stream provides the western boundary, which along with other ocean gyres, such as the North Equatorial Current, encircles the Sargasso. According to Ginsberg (1996), Portuguese sailors named the area for its seaweed since the seaweed's bulbous floats are similar to grapes (sargaco is the Portuguese word for grape). Sargassum seaweed floats in patches and grows through budding. The warm waters of the Sargasso Sea are low in nutrients, which is attributed to its isolation from the deeper, nutrient rich, cold waters (average depth greater than 3 miles). Plankton production is about one-third the oceanic average, however, tiny crabs, shrimp, octopus and other marine animals are abundant among Sargassum.

Although specific spawning areas used by American eel and their habitat parameters have not been identified, Miller (1995) reported two major distribution patterns for leptocephali. The highest abundance of leptocephali were identified in areas located near fronts in the west of the Subtropical Convergence Zone (STCZ). The smallest leptocephali were reported by Miller (1995) to have been collected near the Bahama Banks in the Florida Current and at stations close to the southerly fronts in the western STCZ. Miller (1995) attributes the concentration of leptocephali to "entrainment by anticyclonic circulation northeast of the northern Bahamas."

American eel from throughout their range are believed to synchronize their arrival at the spawning grounds. Morphological and physiological evidence suggests that they may spawn in the upper few hundred meters of the water column (Kleckner et al. 1983, McCleave and Kleckner 1985). Spawning has been inferred to take place from February to April within a broad area in the vicinity of the Sargasso Sea between 52° to 72 ° W longitude and 19 ° and 29 ° N latitude (McCleave et al. 1987). Kleckner et al. (1983)

suggested that thermal fronts separating the northern and southern water masses of the Sargasso Sea form the northern limit of American eel spawning and that some feature of the surface water mass in the southern Sargasso Sea serves as a cue for adult American eel to cease migration and begin spawning activity. After spawning, the spent eel are assumed to die (Facey and Van Den Avyle 1987).

American eel are dioecious, oviparous, and rely on external fertilization. Fertilized eggs reached the gastrula stage before dying 15 h later at 20 ° C (Sorensen and Winn 1984). Artificially spawned Japanese eel (*Anguilla japonica*) are known to hatch in 38-45 hours at 23 ° C (Yamamoto and Yamauchi 1974). Spawning occurs in winter and early spring (Wippelhauser et al. 1985, Kleckner and McCleave 1985, McCleave et al. 1987) probably in association with, or delimited by, density fronts meandering east-west in the Sargasso Sea (Kleckner and McCleave 1988). Eggs hatch in about two days in the warm water (Yamamoto and Yamauchi 1974), releasing the leptocephali. Knowledge of the spawning area is based on the distribution of the smallest leptocephali, as adults have never been observed in the Sargasso Sea.

Leptocephali are transported from the spawning grounds to the eastern seaboard of North America by the Antilles Current, the Florida Current, and the Gulf Stream (Facey and Van Den Avyle 1987). The leptocephali drift and swim in the upper 300 m of the ocean for several months, growing slowly to a length of 5-6 cm (Kleckner and McCleave 1985). Most planktonic leptocephali undergo metamorphosis into glass eel at 5.5-6.5 cm in length at 8 to 12 months of age (Facey and Van Den Avyle 1987), that actively migrate from the offshore waters to the coastal embayments and rivers. American eel apparently take advantage of inflowing tides to move into tidal areas (Wippelhauser and McCleave 1987).

Nursery and Juvenile Habitat

Glass eel enter estuaries and ascend the tidal portion of rivers during winter and spring, earlier in the southern portion of the range, later in the northern portion (Helfman et al. 1984a, McCleave and Kleckner 1982) by drifting on flood tides and holding position near bottom on ebb tides, a migratory tactic known as selective tidal stream transport (McCleave and Kleckner 1982, Wippelhauser and McCleave 1987). Glass eel also ascend by active swimming along shore in the estuaries (Sheldon and McCleave 1985), and above tidal influence (Barbin and Krueger 1994).

Upstream migrating glass eel metamorphose into elvers. Glass eel and elvers burrow or rest in deep water during the day (Deelder 1958). Upstream migrations may be triggered by changes in water chemistry caused by the intrusion of estuarine water during high spring tides (Sorensen and Bianchini 1986).

Limited work on preferred freshwater habitats indicates both lentic and lotic habitats are used and growth appears to be more related to density and availability of food than to water body (Oliveira and Krueger 1999). Bigelow and Schroeder (1953) reported that some elvers are able to surmount obstacles such as falls, dams, and damp rocks during their upstream migrations.

Observation of elver migrations in coastal Rhode Island streams indicates that the main concentration of elvers required about one month to move a distance of 200 m above the tidal zone in a stream with an average gradient of 4 m/km (Haro and Krueger 1991). Elvers orient to river currents for their upstream migration (Tesch 1977) and are strongly attracted to the odor of decaying leaf detritus (Sorensen 1986). Further migration may occur gradually for months or even years (Haro and Krueger 1991).

Elvers exhibit drab pigmentation, dark on the back and often yellowish on the ventral surface, leading to the name yellow eel for this stage. Yellow eel inhabit a variety of habitats and feed opportunistically on various bottom-and near bottom-dwelling animals, mostly invertebrates and slower fishes (Ogden 1970, Wenner and Musick 1975, Facey and LaBar 1981, Lookabaugh and Angermeier 1992, Denoncourt and Stauffer 1993).

Telemetry studies showed that yellow eel in a tidal creek were generally inactive during the day and active at night (Helfman et al. 1983). Growth rates of yellow eel are quite variable, reflecting both latitude (slower growth in the north) and productivity of the habitat, perhaps sex, and probably some difficulty in interpreting putative annual rings in otoliths. Even within a habitat, growth rates of individuals are variable. In Lake Champlain, Vermont, weight of eel was well predicted by length (variation in length accounting for 93% of the variation in weight), but age was poorly predicted by length (accounting for only 27% of the variation in age) (Facey and LaBar 1981). Illustrating the latitudinal trend in length, eel five years of age post-metamorphosis from Georgia averaged about 40 cm long (Helfman et al. 1984b), from South Carolina about 50 cm (Harrell and Loyacano 1980; Hanson and Eversole 1984), while in New Jersey they were about 25 cm (Ogden 1970), and in Newfoundland only about 28 cm (Bouillon and Haedrich 1985). However, the trend is complicated by the habitat variability. In an estuarine habitat in Georgia, five-year-old eel averaged 38 cm, while in two freshwater habitats they averaged 33 cm and 40 cm (Helfman et al. 1984).

Adult Habitat

Yellow eel metamorphose into silver eel and migrate seaward to their spawning grounds. The American eel that are in freshwater drop downstream, traveling mostly at night (Bigelow and Schroeder 1953). During outmigration, adults may inhabit a broad range of depths throughout the water column. Turbine entrainment mitigation efforts at hydroelectric projects may be complicated since bypass systems must be accessed throughout the full depth of the turbine forebay (Richkus and Whalen 1999).

Adult oceanic habitat requirements are not known. However, American eel have been taken at depths greater than 6000 meters.

1.4.1.2 Identification of Habitat and Habitat Areas of Particular Concern

1.4.1.2.1 Ocean

Importance: Spawning - Reproduction for the panmictic population occurs in the Sargasso Sea, therefore, the area used for reproduction might be identified as a habitat area of particular concern. Until recently, no threats to the functional health of this area had been reported.

Concern: Sargassum seaweed is currently harvested in U.S. waters by trawling primarily by one company. The harvesting of sargassum began in 1976, but has only occurred in the Sargasso Sea since 1987. Since 1976, approximately 44,800 dry pounds of sargassum have been harvested, 33,500 pounds of which were from the Sargasso Sea (SAFMC 1998). It is unknown whether this harvest is having direct or indirect influences on American eel mortality. Harvesting sargasssum is being eliminated in the south Atlantic EEZ and State waters by January 1, 2001 through a management plan adopted by the South Atlantic Fisheries Management Council (SAFMC 1998). The extent of eel bycatch in these operations is unknown. The drift of leptocephalus larvae from the Sargasso Sea towards the Atlantic coast may be impacted by changes in the ocean currents. Such changes have been predicted to be due to global warming. The potential impact on the drift of larvae is unknown at this time. Currents, primary production, and potential influence of toxins transferred from the adults to the eggs influence the success of hatch, larval migration, feeding and growth.

1.4.1.2.2 Continental shelf

Importance: Larval migration, feeding, growth; juvenile metamorphosis, migration, feeding and growth.

Concern: Glass eel survival (growth, distribution and abundance) is probably impacted by a variety of activities. Channel dredging, shoreline filling, and overboard spoil disposal are common throughout the Atlantic coast, but currently the effects are unknown. Additionally, these activities may damage American eel benthic habitat. However, the significance of this impact also remains unknown. Changes in salinity in embayments, as a result of dredging projects, could alter American eel distribution.

1.4.1.2.3 Estuaries/Rivers

Importance: Juvenile, sub-adult and adult migration corridors and feeding and growth areas for juvenile and sub-adult.

Concern: Elver and yellow eel abundance is probably also impacted by physical changes in the coastal and tributary habitats. Lost wetlands or access to wetlands and lost access to the upper reaches of tributaries have significantly decreased the availability of these important habitats with wetland loss estimated at 54% (Tiner 1984), and Atlantic coastal tributary access loss or restriction estimated at 84% (Busch et. al 1998).

Habitat factors are probably impacting the abundance and survival of yellow and silver eel. The nearshore, embayments, and tributaries provide important feeding and growth habitat. The availability of these habitats influences the density of the fish and may influence the determination of sex. Therefore, since females may be more common in lower density settings (Krueger and Oliveira 1999, Roncrati et al. 1997, Holmgren and Mosegaard 1996, Vladykov 1966, Liew 1982, Columbo and Rossi 1978), it is crucial that the quantity and quality of these habitats be protected and restored (including upstream access). The blockage or restriction to upstream migration caused by dams reduces or restricts the amount of available habitat to support eel distribution and growth. Fish that succeeded to reach upstream areas may also face significant stresses during downstream migration. If eel have to pass through turbines, mortality rates range from 10 to 60 percent (J. McCleave, U. of Maine, Person. Com.) and the amount of injury is not well documented.

An estimate of nearshore habitat area was obtained from NOAA's Average-Annual, Three-Zone Salinity Metadata and for coastal stream length from Busch et al. (1998) as summarized in Table 4. Although the nearshore zones have been changed due to anthropogenic activities such as dredging, filling, discharges of waste and contaminants and the introduction of exotic species, nearshore habitat trend data are not available for this area. Preliminary data describing trends in lost stream habitat (access length) are presented in Section 1.4.1.2.3.3.

Table 4. Estimated current nearshore habitats (area) and length of access to historic river habitats (potential if currently restricted). Some geographic overlap occurs between the areal (nearshore) and linear (coastal rivers) habitat descriptions (Busch et al 1998).

Habitat		North Atlantic	Mid Atlantic	South Atlantic
Near-shore	Seawater Zone (>25ppt)	5,096 km^2	8,382 km^2	2,713 km^2
	Mixing Zone (0.5 – 25ppt)	229 km^2	10,969 km^2	8,300 km^2
	Tidal Fresh Zone (<0.5ppt)	54 km^2	947 km^2	1,159 km^2
Length of Coastal Rivers	Historic (unrestricted)	111,482 km	199,312 km	246,007 km

The nearshore area totals are the summation of areas designated by NOAA by drawing boundary lines across open water from shorelines. NOAA's Coastal Assessment Framework (CAF) provided the geographics for the shorelines. Busch et al. (1998) used computer databases and a Geographic Information System to assess the quantity of historic (unrestricted) stream habitat available to American eel.

1.4.1.2.3.1 Access to Tributaries

Large numbers of elvers and yellow American eel migrate inland from coastal waters each year, but obstructions such as dams impede migrants in reaching appropriate upstream habitat. Because of their small size and limited swimming speed, elvers and young eel depend on tides to aid upstream migration. Altering stream flows may limit upstream recruitment. Although elvers will attempt to scale wetted substrates such as dam faces, for many of the migrants dams probably limit migration (Tesch 1977). Cost effective passageways designed specifically for elvers and eel have been developed and tested in Europe, Canada, and New Zealand. Knowledge of where migrants accumulate at a barrier and of migrant size (length) is necessary for construction of passageways.

Downstream passage at hydropower dams may represent a major source of mortality to pre-spawning adults (Ritter et al 1997), but has received relatively little attention. Mortality rates for European eel are reported to range from 5-30% depending on turbine type and river flow (Hadderingh 1994). The design of downstream passageways and the use of non-generating periods to reduce eel mortality is hindered by lack of knowledge of the downstream migration. For example, the environmental cues that trigger migration, the depth of migration, and the effects of light and water currents on eel behavior during migration, are all unknowns.

1.4.1.2.3.2. Fish passage

Fish passage is getting attention through the licensing or relicensing of dams for hydropower production and navigation. Upstream fish passage is usually a requirement but construction activities are mostly in the planning process. However, more than 90% of dams on the eastern seaboard are not hydroelectric facilities, and therefore have not been subject to continual relicensing and fish passage analysis.

Downstream passage of silver eel is a problem in streams with hydropower production facilities. Although the industry has been researching effective deterrence to passage mortality, turbine caused damage or mortality continues to be a problem.

1.4.1.2.3.3 Quantity-Stream Habitat

Busch et al (1998) used an ecosystem health assessment approach, developed for the Lake Ontario watershed (Busch and Lary 1996), to determine that Atlantic coastal streams from Maine to Florida have 15,115 dams that can hinder or prevent upstream and downstream fish movement. This results in a restriction or loss of access for fish to 84 percent of the stream habitat within this historic range. This is a potential reduction from 556,801 kilometers to 90,755 kilometers of stream habitat available for migratory and diadromous species such as American eel. The analyses were based upon the regional boundaries established by the USEPA database (Figure 8) and excluded obstruction caused by most natural barriers.

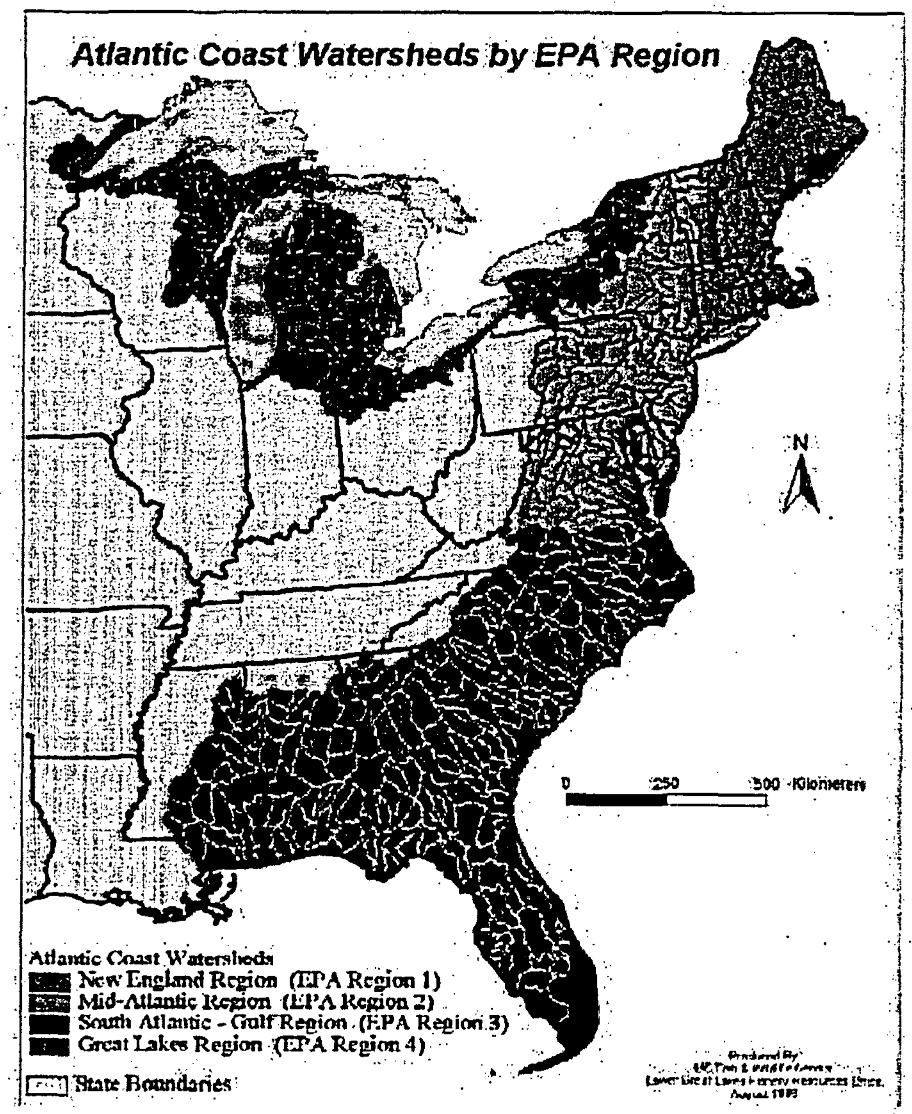


Figure 8. The regional boundaries from the USEPA database as used by Busch et al. (1998)

By region, the potential habitat loss was greatest (91%) in the North Atlantic region (Maine to Connecticut) where stream access is estimated to have been reduced from 111,482 kilometers to 10,349 unobstructed kilometers of stream length (Table 5). Stream habitat in the Mid Atlantic region (New York through Virginia) is estimated to have been reduced from 199,312 km to 24,534 km of unobstructed stream length (88% loss) (Table 6). The stream habitat in the South Atlantic region (North Carolina to Florida) is estimated to have decreased from 246,007 km to 55,872 km of unobstructed stream access, a 77% loss (Table 7).

Table 5. Eel habitat, North Atlantic region (Maine to Connecticut)

Huc4 Number and Watershed Name	Historical length (km)	Current Length (km)	Number of dams	Dams <10 ft.	Dams 10-24 ft.	Dams 25+ ft.	Hydro-Electric	Nav.
101 St. John River Basin	11,335	148	37	3	19	15	10	0
102 Penobscot River Basin	15,245	207	75	9	49	17	53	0
103 Kennebec River Basin	9,186	208	97	11	66	20	54	0
104 Androscoggin River Basin	4,467	195	95	15	57	23	54	0
105 Maine Coastal – St. Croix	10,884	5,166	98	22	69	7	34	0
106 Saco, ME, NH, MA	9,414	1,685	212	28	155	29	74	0
107 Merrimack River Basin	11,006	10	533	87	348	98	93	0
108 Connecticut River Basin	20,874	99	941	93	538	310	119	0
109 MA-RI Coastal Area	7,886	1,589	708	133	487	88	13	4
110 Connecticut Coastal	10,335	1,188	713	42	467	203	49	0
111 St. Francois Rriver Basin	850	1	13	5	5	3	8	0
Totals	111,482	10,348	3,522	448	2,260	813	561	4

Table 6. Eel habitat, Mid Atlantic region (New York through Virginia)

Huc4 Number and Watersheds Name	Historical length (km)	Current Length (km)	Number of dams	Dams <10 ft.	Dams 10-24 ft.	Dams 25+ ft.	Hydro-Electric	Nav.
201 Richelieu Basin including Lake Champlain drainage	9,126	1	235	24	125	83	68	1
202 Upper Hudson	22,389	1	660	91	373	194	64	17
203 Lower Hudson – Long Island	7,781	1,431	519	64	324	127	8	0
204 Delaware Coastal Area	26,934	5,148	1068	179	656	231	21	0
205 Susquehanna River Basin	52,331	251	684	75	324	285	19	2
206 Upper Chesapeake	14,884	8,862	157	13	93	51	3	0
207 Potomac River Basin	28,140	3,281	443	7	141	295	12	0
208 Lower Chesapeake	37,727	5,559	884	22	527	337	22	0
Totals	199,314	24,533	4650	475	2563	1603	217	20

Table 7. Eel habitat, South Atlantic region (North Carolina to Florida)

Huc4 Number and Watershed Name	Historical length (km)	Current Length (km)	No. of Dams	Dams <10 ft.	Dams 10-24 ft.	Dams 25+ ft.	Hydro Electric	Nav.
301 Chowan-Roanoke Coastal Dr.	36,775	3,632	371	3	257	230	15	0
302 Neuse-Pamlico Coastal Dr.	23,324	12,452	445	6	268	149	1	0
303 Cape Fear Coastal Dr.	20,471	5,990	626	5	385	226	9	3
304 Pee Dee Coastal Dr.	35,880	6,139	1034	58	637	333	10	0
305 Edisto-Santee Coastal Dr.	41,504	7,003	1942	52	1073	810	66	0
306 Ogeechee-Savannah Coastal Dr.	34,604	4,508	1028	33	546	447	30	1
307 Altamaha-St. Marys Coastal Dr.	37,172	4,673	1353	31	763	559	10	0
308 St. Johns Coastal Dr.	82,334	6,582	40		18	19	0	4
309 Southern Florida Coastal Dr.	8,044	4,893	105	6	46	45	0	0
Totals	246,008	55,872	6944	194	3993	2818	141	8

In the assessment of the Atlantic Coast watersheds, the St. Lawrence River - Lake Ontario watershed was included. However, data were incomplete because only the United States' side of the Lake Ontario basin was assessed. Construction of the Moses Saunders Dam (1954-58) impeded upstream and downstream migration on the St. Lawrence River, restricting access by migratory fish from the Atlantic Ocean to Lake Ontario and the Finger Lakes system. In 1974, an eel ladder was constructed, which probably reduced the effects of the lack of upstream passage at the Moses Saunders Dam. The number of American eel ascending the ladder has decreased dramatically in recent years (see Figure 4).

While a number of American eel have utilized the Saunders eel ladder, an assessment of the percent passed to the total number of eel in the system has not been conducted. It is unknown whether the number currently passed is sufficient to sustain the Saint Lawrence River/Lake Ontario stock.

In the U.S. portion of the watershed, 455 dams result in 24,693 km of stream habitat lost or restricted from a total of 30,085 km (82% loss) to migratory fish originating in or having Lake Ontario as their destination (Table 8). Since dams on the St. Lawrence River hinder fish movement through the St. Lawrence River to and from the Atlantic Ocean, the total kilometers of stream access lost or restricted in the Lake Ontario and St. Lawrence River watershed is actually much larger.

Table 8. Eel habitat, Great Lakes region1 (New York and Ontario to Quebec)

Huc4 Number and Watershed Name	Historical length (km)	Current Length (km)	Number of dams	Dams <10 ft.	Dams 10-24 ft.	Dams 25+ ft.	Hydro-Electric	Nav.
412 Eastern Lake Erie Drainage	113	66	4	0	1	3	3	0
413 Southwestern Lake Ontario Drainage	8,076	1,827	67	7	45	15	9	1
414 Southeastern Lake Ontario Drainage	16,156	2,877	159	33	74	52	19	15
415 Lake Ontario-St. Lawrence Drainage	5,740	622	225	24	118	83	150	2
Totals	30.085	5,392	455	64	238	153	181	18

The dam database used by Busch et al. (1998) included information on dam heights (Tables 5-8). It identified 3,512 dams in the North Atlantic Region of which 448 are less than 10 ft. high, 2,260 are between 10 and 24 ft. high, and 813 are higher than 25 ft. Of all the dams, 561 are used for hydropower production. The Mid-Atlantic Region has 4,650 dams of which 475 are less than 10 ft. high, 2,563 are between 10 and 24 ft. high, and 1,603 are higher than 25 ft. And, 217 dams are used for hydropower production. In the South Atlantic Region, the 6,944 dams identified included 194 that are less than 10 ft. high, 3,993 between 10 and 24 ft., and 2,818 higher than 25 ft. Of the dams in this region, 141 are used for hydropower production. Dams in the US Lake Ontario basin include 64 that are less than 10 ft. high, 238 that are 10-24 ft. high, and 153 that are 25 ft. or higher. Hydropower production was the use identified for 181 dams.

1 No Canadian data were available, therefore, data presented are only from the U.S. side of Lake Ontario.

Various factors influence successful upstream or downstream migration of American eel past dams. Busch et al. (1998) evaluated fish migration restrictions due to dams by examining limited data on the presence or absence of American eel above and below dams. The preliminary results indicate that although height and use (purpose) for the facility appear to be important factors, other criteria need to be evaluated including slope, construction material, water flow, location of the dam in the watershed, and operational procedures.

Dams that require special licenses such as for hydropower production or navigation provide opportunities for fish passage if required by the resource management agencies. However, only 1,100 were identified for hydropower production and 50 for navigation out of the total number of 15,570 identified dams. Therefore, only 7% of these dams are covered by regulatory programs that could provide fish passage. The other specific uses for dams identified in the database include water-level control, water supply, and recreation.

Downstream passage to the American eel's historic habitat is just as important as successful upstream access. Therefore, turbine-induced mortality during downstream migration needs to be resolved since it impacts prespawning adult silver eel. Investigations have found turbine-induced mortality of eel to range from 5 to 60%, depending on the flow through the turbines and on the length of the fish (Hadderingh 1990; McCleave Person. Comm.). Experiments using lights to deflect American eel from water intakes into bypass areas have been successful at some hydroelectric power stations (Hadderingh 1990). The reduced numbers of American eel which currently utilize Lake Ontario tributaries, such as the Oswego River, presumably move upstream via the locks and require downstream passage in order to reach Lake Ontario. Haro (1996) also provides information on various methods of mitigating turbine entrainment and mortality by diverting eel around turbine intakes to bypass entrances during downstream migration. Experiments carried out using behavioral mitigation techniques such as strobe lighting have shown some success in diverting eel from turbine intakes. Other behavioral methods such as water and air jet curtains and weak electric fields have not shown similar success (Richkus and Whalen 1999). Research on mechanical mitigation devices such as angled bar racks, louvers, and screens has provided mostly inconclusive although insightful results that might warrant further research (Richkus and Whalen 1999).

1.4.1.2.3.4 Quality

Temperature: American eel are capable of tolerating a wide range of physiochemical conditions. Elvers have been found in waters as low as -0.8 ° C (Jeffries 1960). Yellow eel held at less than 5 ° C for over 5 weeks stopped feeding and reduced their oxygen consumption (Walsh et al. 1983). Yellow eel are known to hibernate in the mud during the winter (Fahay 1978). Preferred summer temperatures have been reported at 17.4 ± 2 ° C for yellow eel (Karlsson et al. 1984). American eel are apparently capable of surviving short-term thermal shocks. American eel have been reported to survive passage through a nuclear power plant, during which they were exposed to elevated temperatures for 1 to 1.5 h (Marcy 1973).

Salinity: Little work has been done on the salinity requirements of American eel. The leptocephali have been reported to be in near-ionic equilibrium with sea water (Hulet et al. 1972). Elvers are known to delay their upstream migration at the freshwater brackish interface which is believed to permit some physiological adjustments to the new freshwater regime (Sorensen and Bianchini 1986). Yellow eel occupy niches in freshwater and brackish regimes. Silver eel migrate from freshwater to the open ocean. From the above, postlarval American eel appear to be euryhaline.

1.4.1.3 HABITAT ISSUES

Habitat includes the physical, chemical and biological setting and requirements needed to support all life functions of American eel.

Spawning Areas

Spawning takes place in the Sargasso Sea. The specific location(s) and the specific habitat characteristics in this 5.2 million km^2 (2 million $miles^2$) area have not been reported. Loss of spawning habitat would result in significant impacts on American eel. Threats to American eel populations and spawning habitat include sea level rise / land subsidence, and contaminants. Global warming and the subsequent rise in sea level could adversely affect American eel spawning activities. Sea level is predicted to rise above current levels by approximately 50 centimeters to 1 meter by the year 2100 (Oerlemans 1989, Titus et al 1991). The effects on this sea level rise on the currents and oceanic conditions that conduct larval migration are completely unknown. Land subsistence along the Atlantic Coast adds to the effect of sea level rise, resulting in an increase of 25-30 centimeters greater than the global average (Hull and Titus 1986). Such an increase could fundamentally alter current eel habitat. In addition, American eel accumulate significant amounts of contaminants in reproductive tissue. Thus, the potential to impair reproduction, if contaminants are not carefully monitored in important eel habitats.

Feeding and Growth Areas

Data from commercial harvest records for elvers/glass eel, yellow eel and stock assessments indicate that eel are found in most types of habitat including the offshore, mid-water and bottom areas of estuaries, embayments, rivers, streams, and lakes. However, eel are found to be most prevalent in the nearshore, shallow embayments and tributaries (Adams and Hankinson 1928; Facey and LaBar 1981; Helfman et al. 1983; GLFC 1996; NYSDEC 1997a & b).

American eel are classified as a warmwater species (Adams and Hankinson 1928) that are most abundant in relatively warm streams and shallow lakes or embayments (Ogden 1970), while relatively scarce in deep, steep gradient cold-water lakes (Smith and Saunders 1955). Limited work on preferred freshwater habitats indicates both lentic and lotic habitats are used and growth appears to be related to density and availability of food (Krueger and Oliveira 1999). Stream use appears to be important to elvers (Bigelow and Schroeder 1953) and yellow eel.

Issues and Concerns

Various habitat stresses and losses impact American eel abundance, health, distribution, and growth rates (Lary and Busch 1997; Richkus and Whalen 1999). These impacts have not been adequately described. Furthermore, since habitat management is also the responsibility of agencies other than the primary participants in the ASMFC, habitat issues need to be addressed through interagency coordination and other avenues (i.e., legislation, policy, enforcement, etc.).

Channel dredging and overboard spoil disposal are common throughout the Atlantic coast, but currently have unknown effects on American eel. Changes in salinity as a result of dredging projects could alter American eel distribution. Additionally, dredging associated with whelk and other fisheries may damage American eel benthic habitat; however, the significance of this impact also remains unknown.

Although pollution has the potential to adversely impact all the life stages of American eel, there are no data to suggest unusual sensitivity by American eel to urban or agricultural contaminants (e.g., pesticides and herbicides). However, due to their longevity and habitat use, high levels of contaminants have been reported in eel (Hodson et al. 1994). Additional information needs to be obtained to determine the impacts of contaminants on American eel. Also a new, specific area of concern deals with coastal wetlands and the potential impact caused by spraying insecticides for mosquito control at the time glass eel enter these areas. Potential impacts from contaminants include mortality, changes in behavior, and decreases in fecundity.

2.0 GOALS AND OBJECTIVES

2.1 SPECIFICATION OF MANAGEMENT UNIT

The specific "management unit" for this Fishery Management Plan is defined as that portion of the American eel population occurring in the territorial seas and inland waters along the Atlantic coast from Maine to Florida.

Significant numbers of eel use areas/habitats that are outside the jurisdictional boundaries of the state agencies participating in the ASMFC. These include watersheds in the Canadian Atlantic Provinces, upstream freshwaters reaches that are managed by inland fish and wildlife agencies of ASMFC member states and regional institutions such as the Gulf States Marine Fisheries Commission, and those waters within Native American Reservations where Tribal Governments have jurisdiction. U.S. eel management needs to proactively include and coordinate the interests and approaches of the ASMFC with applicable jurisdictions/agencies in order to implement holistic management, including protection and enhancement of this species.

Since all eel reproduction occurs in the Sargasso Sea (Figure 2), the health and availability of this area to support reproduction is of significant importance. Activities impacting the health of the Sargasso Sea and reproductive success of eel, although outside direct management of the ASMFC, need to be addressed through other applicable authorities. The Secretary of Commerce and the National Marine Fisheries Service may take complementary management action in the Exclusive Economic Zone, as per the recommendations in Section 4.2.2.

The Goals of the Fishery Management Plan for American Eel are to:

1. Protect and enhance the abundance of American eel in inland and territorial waters of the Atlantic States and jurisdictions and contribute to the viability of the American eel spawning population; and

2. Provide for sustainable commercial, subsistence, and recreational fisheries by preventing overharvest of any eel life stage.

Primary Objectives

1. Improve knowledge of eel harvest at all life stages through mandatory reporting of harvest and effort by commercial fishers and dealers, and enhanced recreational fisheries monitoring;
2. Increase understanding of factors affecting eel population dynamics and life history through increased research and monitoring;
3. Protect and enhance American eel abundance in all watersheds where eel now occur;
4. Where practical, restore American eel to those waters where they had historical abundance but may now be absent by providing access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel; and
5. Investigate the abundance level of eel at the various life stages, necessary to provide adequate forage for natural predators and support ecosystem health and food chain structure.

Long-Term Objectives

A Encourage protection of eel spawning, nursery and growth habitats with and/or through the agencies having jurisdiction over these areas;

B Protect and enhance inland and coastal water quality to protect the health of the eel population and to reduce bioaccumulation of toxic substances; and

C Coordinate harvest and abundance monitoring with resource management agencies outside the East Coast of the U.S.

3.0 MONITORING PROGRAM SPECIFICATIONS/ELEMENTS

The American Eel FMP encourages all state fishery management agencies to pursue full implementation of the Atlantic Coastal Cooperative Statistics Program (ACCSP), which will meet the monitoring and reporting requirements of this FMP. The American Eel FMP recommends a transition or phased-in approach be adopted to allow for full implementation of the ACCSP. Until such time as ACCSP is implemented, the American Eel FMP encourages state fishery management agencies to initiate implementation of specific ACCSP modules, and/or pursue pilot and evaluation studies to assist in development of reporting programs to meet the ACCSP standards (please refer to the ACCSP Program Design document for specific reporting requirements and standards; Contact - Joe Moran, ASMFC). The ACCSP partners are the 15 Atlantic coastal states (Maine – Florida), the District of Columbia, the Potomac River Fisheries Commission, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, the three fishery management Councils, and the Atlantic States Marine Fisheries Commission. Participation by program partners in the ACCSP does not relieve states from their responsibilities in collating and submitting harvest/monitoring reports to the Commission as may be required under this FMP.

Management of American eel will be based on scientific advice provided by the scientific community, as well as input from public hearings and from the Advisory Panel. Management will strive for a long-term viable population, supporting fisheries and inter-dependent wildlife populations. Effective management will require monitoring population abundance at various life stages, monitoring fishing mortality (harvest and incidental), preventing habitat degradation, restoring fish habitat, as well as identifying and supporting research. The measures outlined below are designed to facilitate the management process. As new data become available and new assessment data provide new perspective, management elements will adapt in order to most effectively reach the goals and objectives.

3.1 ASSESSING ANNUAL RECRUITMENT

Little is known about annual recruitment of American eel. Although maximum fecundity can be estimated, natural larval mortality is estimated to be substantial. The number of larvae that survive to reach the coastal areas each year and transform to glass eel is unknown. Also, the annual variation in recruitment to elvers or yellow eel is unknown, as is the number that survive to sexual maturity. Because American eel are slow maturing and long-lived, current juvenile indexing techniques have limited applicability in describing the annual abundance and variations in the abundance of respective cohorts. This is due to the variability in age/length relationships, and therefore similar size classes of eel will include a number of year classes. Resolution of the aging issue requires further investigation and validation of techniques used for age determination, as is mentioned in Section 6 "Information and Research Needs." Additional information regarding larval and juvenile survival is essential to assessing annual recruitment. Monitoring abundance of American eel for each of the defined life stages will be necessary for the establishment of multiple recruitment indices.

3.1.1 Annual Young-of-Year Abundance Survey

The glass eel and elver (young-of-year) life stages provide the most unique opportunity to assess the annual recruitment of each year's cohort since young-of-year result from the previous winter's spawning activity, and hence are all the same age. Known age is an attractive feature of the young-of-year life stage, which has shown to be problematic with all older life stages. Therefore, a fishery independent young-of-year abundance survey is proposed in accordance with the options provided below.

Measurement of young-of-year abundance is considerably cost effective since the gear required is inexpensive to purchase or manufacture, requires no additional expense for bait, and may be operated by relatively few persons. Also, since the young-of-year life stage and period of recruitment onto the Atlantic coast is short in duration, each annual assessment of young-of-year abundance would not amount to a long commitment of staff time.

Data from a young-of-year abundance survey could provide a barometer with which to gauge the efficacy of management action, given due consideration to the factors which affect spawning, larval survival, transport, metamorphosis, and subsequent recruitment of young-of-year onto the Atlantic coast. Young-of-year abundance indices may also provide a basis of inference for the future abundance of each year's cohort, similar to abundance indices validated for other fish species.

Accordingly, states/jurisdictions will conduct annual fishery-independent surveys for young-of-year American eel. Each participating jurisdiction shall deploy appropriate gear to capture young of the year at a minimum of two locations over a six-week period. A variety of gear types are available for use, and states should use the gear most suitable to the habitat and geography within their jurisdiction. The cost of most gear ranges from $200 to $400 per unit.

The timing and placement of the young-of-year sampling gear will coincide with those periods of peak onshore migration of young-of-year. The locations selected will be those previously shown to catch young-of-year American eel and should provide as wide a geographic distribution as possible. Initially, stock assessment biologists may need to alter the timing and placement of the sampling gear in order to determine peak migration period and locations for the annual survey. Thereafter, standard stations and procedures will remain fixed.

At a minimum, the gear will be set so that they are operational during periods of rising or flood tides occurring at nighttime hours. During these conditions, gear will be checked as often as possible and emptied of their catch. The catch will be sorted and all specimens identified to their lowest taxonomic order, measured, weighed and enumerated as appropriate. Species which appear to be predators of young-of-year will be denoted. The entire catch of young-of-year will be weighed and counted, and each individual measured for total length. The number of young-of-year per unit weight (gram) will be determined for each catch examined. Standard statistical techniques (sub-sampling) will be used in instances where the catch of young-of-year is too large (i.e., several hundred individuals or more) to warrant a complete census.

In addition to the catch and by-catch of young-of-year, various environmental and climatological data will be recorded for each catch. These will include date, water and air temperatures, salinity, tide stage, and soak time. Notation of wind speed, direction and precipitation will be recorded. Also, a subjective judgement of the condition of the gear at the time of sampling will be made on an ordinal scale of one to four, with one equal to good, two equal to fair, three equal to poor, and four equal to void or unsuitable for indexing. The judgement will relate to the condition the gear was found in relation to the condition it was left in the previous day. Young-of-the year captured at or near obstructions should be released upstream of these obstructions whenever possible.

All states/jurisdictions, except those exempted by the Management Board, are required to conduct an annual young-of-year abundance survey, beginning in the year 2000, as described above. The Technical Committee shall advise the Management Board on exemptions as necessary. Those states that are initially exempted will be required to conduct the annual young-of-year survey by the year 2001. States shall submit proposals for instituting their surveys as per Section 5.1.2.

3.1.2 Annual Report of Harvest or Catch Per Unit of Effort

A catch per unit effort (CPUE) reporting requirement will be initiated by every state, if not already required, in order to develop abundance indices for each life stage (see Section 3.4.1 for mandatory reporting requirements).

3.2 ASSESSING SPAWNING STOCK BIOMASS

The annual spawning stock biomass for American eel populations along the Atlantic Coast is unknown. NMFS landings data provide limited estimates of silver eel harvest: 423 tons to 1,813 tons were harvested between 1970 to 1995 from the Atlantic coast. The New England and Mid-Atlantic regions of the Atlantic Coast produce the majority of the American eel commercial harvest. However these data are of limited use due to inadequate sampling of inland harvest areas and dealer locations. Also, since the harvest data from a number of inland and marine agencies may include a number of species and an unknown ratio of mature (silver) and maturing (yellow) eel, the current fishery dependent data are inadequate to describe the annual abundance and variations in abundance between years. In short, any estimate of abundance or population trends based on existing harvest data is questionable because of inconsistent reporting requirements across jurisdictions. Furthermore, fishery independent abundance data are generally lacking.

3.2.1 Fishery-independent monitoring of adults/sub-adults.

The silver or migratory stage of American eel provides an opportunity to monitor the abundance of the spawning stock. Although these fish will be of various sizes and ages, they are on their way to reproduce and will jointly contribute to the abundance of the next cohort. Therefore, the fishery independent reporting of emigrant counts, should be maintained, standardized, and expanded. In addition, certain ongoing/recent state surveys for eel abundance and distribution may be useful for fishery-independent monitoring of silver and yellow eel populations.

3.3 ASSESSING MORTALITY

American eel mortality has three components: natural, fishing, and incidental. Natural mortality includes factors such as predation and disease; fishing mortality includes harvest and bycatch; incidental mortality includes anthropogenic impacts from fish passage (for example through hydroelectric turbines), chemical spills or hazardous chemical exposures.

A sustainable mortality rate will allow for a certain level of harvest and incidental losses while still maintaining a viable spawning stock biomass. This rate has not been calculated for eel because of the difficulty in obtaining abundance data (population and harvest) by age throughout the species' range. Combined mortality at all life stages in salt and fresh water is largely responsible for controlling the population size of American eel across its range.

3.3.1 Natural Mortality

Although not documented, natural mortality is presumed to be very high at the leptocephalus stage, glass eel and elver stages due to the high fecundity of the species. This notion is based on the high fecundity (Wenner and Musick 1974; Barbin and McCleave, 1997) of this species. Natural mortality for yellow and silver eel also lack documentation.

3.3.2 Fishing Mortality

Fishing mortality has two components: directed fishing mortality (e.g., intentional harvest) and non-directed mortality (e.g., by-catch). Although reported commercial landings data show a continuing decrease in harvest since the late 1970's, changes in fishing effort or mortality rates are not available. This situation will be addressed through the implementation of the harvest reporting requirements outlined in Section 3.4.1, and the ability to use consistent harvest data in future stock assessments.

The amount of American eel bycatch in commercial and recreational fisheries remains unknown. Additional information will be required to determine the impact of bycatch. It is likely that bycatch of American eel are commonly discarded in the recreational fishery and unreported in total harvest. Bycatch for American eel should be quantified within a bycatch-monitoring module of the Atlantic Coastal Cooperative Statistics Program (ACCSP).

3.3.3 Incidental Mortality

As defined in this FMP, incidental mortality is also caused by anthropogenic activities other than harvest. Activities include damming (e.g., impingement, entrainment, and turbine caused injury) navigation locks (e.g., impingement, entrainment), industrial/municipal water intakes (e.g., impingement, entrainment), and those caused by chemicals (drastic salinity changes, spills, point source releases, and non-point source releases such as the application of insecticides in glass eel nursery areas). Accumulated contaminants may impact individuals directly as well as egg viability and larval survival. Compression of range through habitat restrictions may increase the significance of predation mortality.

More research is needed on the extent and impact of incidental mortality in order to improve future stock assessments. See Section 6.3 for related research recommendations.

3.4 SUMMARY OF MONITORING PROGRAMS

Numerous state and federal agencies, universities, and private organizations are involved in data collection programs to directly determine American eel population status. While existing monitoring programs may be useful in identifying general trends within specific areas if consistent data have been collected, each is complicated by factors that may bias the data, such as sampling error, inappropriate equipment, or incomplete sampling effort. Most existing fishery dependent and independent monitoring programs lack a comprehensive data collection goal.

The goal of a comprehensive American eel monitoring program is to produce the data needed to obtain an accurate assessment of the American eel population for making management decisions. States must improve the reporting of eel harvest data by gear, season, and harvest effort and life stage, as well as fishery-independent data.

In order to collect information to support accurate management decisions, a comprehensive monitoring plan must be developed. Such monitoring efforts should be standardized and be conducted in each of the cooperating states within the ASMFC. Fishery-dependent reporting requirements will include pounds landed, harvest method, gear, season, effort, and life stage (see

Section 3.4.1). In addition, the NMFS Marine Recreational Fisheries Statistics Survey (MRFSS) and state surveys should be utilized to collect catch, harvest, and biological information regarding recreational and subsistence fisheries for American eel. States/jurisdictions are encouraged to fund expansion of the survey inland, where significant recreational fisheries for catadromous and anadromous fish are reported to occur. Lack of such information could have serious consequences in the assessment of the American eel stock. Wherever practical, state harvest reporting requirements will coincide with the current and future mandates of the ACCSP. Reporting elements not covered by the ACCSP should be covered by annual reports submitted in conjunction with this FMP.

3.4.1 Annual State Report on Regulations, Harvest, Bycatch and Fishery-Independent Surveys for American Eel.

Each state/jurisdiction shall be required to submit an annual report (in accordance with Section 5.1.2) detailing that state's regulations, catch, harvest, bycatch, fishery dependent and independent surveys, and characterization of other losses for American eel. The report will address each of the topics listed below.

1. Commercial fishery
   a. Synopsis of regulations in place
   b. Estimates of directed harvest, by month, by region as defined by the states
      1. Pounds landed by life stage and gear type (defined in advance by ASMFC)
      2. Biological data taken from representative sub-samples to include sex ratio and age structure (for yellow/silver eels), length and weight if available
      3. Estimated percent of harvest going to food versus bait
   c. Estimates of export by season (provided by dealers)
   d. Harvest data provided as CPUE (by life stage and gear type)
   e. Permitted catch for personal use, if available
2. Recreational fishery
   a. Synopsis of regulations in place
   b. Estimate of recreational harvest by season (if available)
      1. Biological data taken from representative sub-samples to include sex ratio, age structure, length and weight (if available)
3. Fishery-independent monitoring
   a. Results of the Annual Young-of-Year Abundance Survey (unless exempt)
   b. Description of other fishery-independent surveys performed (methods, location, etc.) and results (if required in FMP)
   c. Projects planned for next five years
4. Characterization of Other Losses

To the extent possible states/jurisdictions should attempt to characterize the losses of American eel, in number and weight by life stage or age, due to factors other than commercial and recreational fisheries. Such losses may include, but are not limited to the following:

a. Impingement/entrainment mortalities of eel at power generation facilities, water intakes, and navigation locks
b. Bycatch mortalities in commercial and recreational fisheries
c. Confiscated poundage from illegal or undocumented fisheries (i.e., poaching)

d. Scientific losses (i.e., samples collected for contaminants analysis, other studies)
e. Mass mortalities of eel due to disease, spills or other causes

Commercial Catch and Effort Data Collection Programs

The ACCSP commercial data collection program will be a mandatory, trip-based system with all fishermen and dealers required to report a minimum set of standard data elements (refer to the ACCSP Program Design document for details). Submission of commercial fishermen and dealer reports will be required after the 10th of each month.

Any marine fishery products landed in any state must be reported by a dealer or a marine resource harvester acting as a dealer in that state. Any marine resource harvester or aquaculturist who sells, consigns, transfers, or barters marine fishery products to anyone other than a dealer would themselves be acting as a dealer and would therefore be responsible for reporting as a dealer.

Recreational Catch and Effort Data Collection Programs

The ACCSP recreational data collection program for private/rental and shore modes of fishing will be conducted through a combination telephone and intercept survey. Recreational effort data will be collected through a telephone survey with random sampling of households until such time as a more comprehensive universal sampling frame is established. Recreational catch data will be collected through an access-site intercept survey. A minimum set of standard data elements will be collected in both the telephone and intercept surveys (refer to the ACCCSP Program Design document for details). The ACCSP will implement research and evaluation studies to expand sampling and improve the estimates of recreational catch and effort.

For-Hire Catch Effort Data Collection Programs

The ACCSP is conducting an evaluation study to determine the best method(s) of data collection for for-hire fisheries. A minimum set of standard data elements will be collected in all for-hire catch/effort surveys (refer to the ACCSP Program Design document for details).

Discard, Release, and Protected Species Interactions Monitoring Program

The ACCSP will require a combination of quantitative and qualitative methods for monitoring discard, release, and protected species interactions in commercial, recreational, and for-hire fisheries. Commercial fisheries will be monitored through an at-sea observer program and several qualitative programs, including strandings, entanglements, trend analysis of logbook reported data, and port sampling. Recreational fisheries will be monitored through add-ons to existing intercept surveys and additional questions added to the telephone survey. For-hire fisheries will be monitored through an at-sea observer program and several qualitative programs (refer to the ACCSP Program Design document for details).

3.4.2 Biological Information

The ACCSP will require the collection of baseline biological data on commercial, for-hire, and recreational fisheries. Biological data for commercial fisheries will be collected through port sampling programs and at-sea observers. Biological data for recreational fisheries will be collected in conjunction with the access-intercept survey. Biological data for for-hire fisheries will be collected through existing surveys and at-sea observer programs. A minimum set of standard data elements will be collected in all biological sampling programs (refer to the ACCSP Program Design document for details). Priorities and target sampling levels will be determined by the ACCSP Biological Review Panel, in coordination with the Discard/Release Prioritization Committee.

3.4.3 Social and Economic Information

<u>Commercial Fisheries</u>

The ACCSP will require the collection of baseline social and economic data on all commercial fisheries (refer to the ACCSP Program Design document for details). A minimum set of standard data elements will be collected by all social and economic surveys (refer to the ACCSP Program Design document for details).

<u>Recreational Fisheries</u>

The ACCSP will require the collection of baseline social and economic data on all recreational fisheries through add-ons to existing recreational catch/effort surveys (refer to the ACCSP Program Design document for details). A minimum set of standard data elements will be collected in all for-hire catch/effort surveys (refer to the ACCSP Program Design document for details).

3.4.4 At-Sea Observer Program

The ACCSP at-sea observer program is a mandatory program. As a condition of state and/or federal permitting, vessels should be required to carry at-sea observers when requested. A minimum set of standard data elements will be collected through the ACCSP at-sea observer program (refer to the ACCSP Program Design document for details). Specific fisheries priorities will be determined by the Discard/Release Prioritization Committee.

3.4.5 Vessel Registration System

The ACCSP has recommended the development of a standardized national fishing vessel registration system (VRS) through upgrades and expansions of the current Vessel Identification System (VIS). The VIS is an integration of the Coast Guard documentation and individual state registration systems. A minimum set of standard data elements will be collected through the VIS (refer to the ACCSP Program Design document for details).

4.0 MANAGEMENT PROGRAM IMPLEMENTATION

Management of American eel will be based on scientific advice provided by the Technical Committee, as well as input from public hearings and the Advisory Panel. In general, management will strive for a long-term sustainable population, with a surplus to support recreational, subsistence and commercial fisheries.

Each state must implement the required management measures and should protect American eel habitat within its jurisdiction to ensure the viability of the population segment residing within its boundaries. States must work with Native American tribal nations and other management jurisdictions within their boundaries in the management of American eel resources.

4.1 RECREATIONAL FISHERIES MANAGEMENT MEASURES

Currently there are observed but undocumented recreational fisheries for American eel. The harvest rate is unknown, as is the discard mortality rate of the bycatch of American eel from recreational fisheries for other species.

In order to minimize the chance of excessive recreational harvest, as well as circumvention of commercial eel regulations, the ASMFC member states/jurisdictions shall establish uniform possession limits for recreational fisheries of a six inch minimum size and a possession limit. Recreational anglers may possess no more than 50 eels per person, including crew members involved in party/charter (for-hire) employment, for bait purposes during fishing. Recreational fishermen will not be allowed to sell eel without a State license permitting such activity.

4.2 COMMERCIAL FISHERIES MANAGEMENT MEASURES

States shall institute licensing and reporting mechanisms to ensure that annual effort (including total units of gear deployed) and landings information by life stage (glass eel/elver, yellow eel, and silver eel) are provided by harvesters and/or dealers. In addition, the ACCSP will require a comprehensive permit/license system for all commercial dealers and fishermen.

4.2.1 Management Measures

States/jurisdictions shall maintain existing or more conservative American eel commercial fishery regulations, including gear specifications contained in Table 2, for all life stages. States with minimum size limits for commercial eel fisheries shall retain those minimum size limits, unless otherwise approved by the American Eel Management Board. The provisions listed within this paragraph are considered a compliance requirement and are effective immediately upon adoption of the FMP by the ASMFC.

Management measures include all mandatory monitoring and annual reporting requirements as described in Sections 3.4.1 and 5.1.2. Specifically, harvest, effort, and biological information shall be provided as per Section 3.4 for each life stage exploited in each jurisdiction. Wherever practical, monitoring requirements in Section 3.4.1 are consistent with current and future mandates of the Atlantic Coastal Cooperative Statistics Program (ACCSP). Monitoring elements not covered by ACCSP must still be covered by state agencies and reported as per Section 3.4.1. States may also propose alternative management programs as per Section 4.4.

4.3 HABITAT CONSERVATION AND RESTORATION

Protection of habitat such as nursery area is critical to the continued survival of American eel. Each state should identify, categorize, and prioritize important and historic American eel habitat within areas of its jurisdiction. Periodic monitoring should be designed and implemented to ensure the long-term viability of essential American eel habitat.

Barriers restrict or prevent migration into current and historical habitat, thereby, reducing total production. Successful upstream and downstream fish passage past barriers is essential to ensuring maximum spawning stock biomass of emigrating silver eels from the U.S. Atlantic coast (Lary and Busch, 1997).

In areas where residential and commercial development is adjacent to American eel habitat, state marine fisheries agencies should coordinate efforts with their inland fisheries/wildlife agencies and others (for example, state agencies with responsibility for soil and water conservation and water quality) to implement remedial actions to restore habitat. State marine fisheries agencies should also coordinate with their state water quality agencies responsible for developing and implementing river basin and wetland restoration plans, to ensure that American eel habitat is identified and considered in these plans, and that these plans are implemented. Also, state marine fisheries agencies should coordinate their concerns with the Army Corps of Engineers since they have authority to investigate, study, modify, and construct projects for habitat restoration, under Section 1135(b) of the Water Resources Development Act of 1986, and also under Section 206 of this same Act.

State marine fisheries agencies should coordinate with their state inland fisheries/wildlife agencies to identify migration times, through site-specific data collection and monitoring. This information should be used to provide comment to permitting agencies regarding seasonal restrictions on activities that may disturb or retard eel migration and feeding behaviors. Construction activities should be avoided in critical migration periods. However, the specific seasonal restriction dates for any particular area should be based on site-specific data and appropriate monitoring. States should consider obtaining land adjacent to critical migration corridors and staging areas to ensure their long-term protection. Protection of American eel habitat or areas of particular concern should be pursued through acquisition, deed restrictions, or conservation easements. State fisheries agencies should also work with their state soil and water conservation agencies and/or agricultural agencies to provide information on these habitats, to be used in their decisions regarding the state's riparian buffer program.

4.3.1 Preservation of Existing Habitat

Sargasso Sea

State marine fisheries agencies should be proactive in identifying opportunities to protect the health of the Sargasso Sea area through partnerships with NOAA and NMFS, including the implementation of the SAFMC's Fishery Management Plan for Pelagic *Sargassum* Habitat of the South Atlantic Region (SAFMC 1998).

4.3.2 Habitat Restoration, Improvement, and Enhancement

Reestablishment of Eel into Historic Habitats

ASMFC participating states/jurisdictions marine fisheries agencies are encouraged to collaborate with their sister inland management agencies, as well as with other Federal and State agencies, and Native American governments to mitigate to the extent possible the effects of various hazards to the upstream and downstream migration of American eel. Such mitigation should include, but not be limited to support of fish passage research, requirements for the construction of fish (eel) passage facilities upon construction of dams, power generating facilities and relicensing of same, and outright removal of identified hazards to eel passage.

Upstream passage

State marine fisheries agencies should cooperate with their inland fisheries/wildlife agencies and the USFWS to improve access to upstream reaches of streams currently restricted by dams with no ladders, helping to increase access to more habitat for feeding and growth. Although it is often assumed that navigation locks will provide unhindered upstream access for eel, this is not a proven, effective passageway due to the great fluctuations in water flow during lock operation (Lary and Busch 1997). Trap and truck methods have also been suggested as a process for eel passage. This has not been adequately evaluated as to effectiveness or the impact on the species, such as changes in the natural selection process. However, trap and transport of glass eels and elvers could be a cost effective, short-term method of upstream passage if it involved volunteers or harvesters who returned a portion of their glass eel/elver catch upstream of impassable blockages.

Downstream passage

State and federal agencies should investigate changes in turbine design to improve downstream fish passage and continue efforts to direct eel away from turbine passage to other higher survival passage opportunities. Investigations should also include feasibility of dam shut-downs during off-peak/night time hours to encourage passive escapement of migrating adult eels.

Monitor enhancement efforts

State and federal agencies should monitor and report on the amount of habitat opened through upstream passage projects and any associated changes in emigrating eel abundance. Passability of blockages for different size classes of eels should also be evaluated.

4.3.3 Avoidance of Incompatible Activities

Each state should establish windows of compatibility for activities known or suspected to adversely affect American eel life stages and their habitats (e.g. dredging, filling, aquatic construction) as well as notify the appropriate construction or regulatory agencies in writing.

Projects involving water withdrawal from important habitats (e.g. feeding grounds) should be scrutinized to ensure that adverse impacts resulting from impingement, entrainment, and/or modification of flow, temperature and salinity regimes due to water removal will not adversely impact American eel in any life stage.

Each state which contains growth areas within its jurisdiction should develop water use and flow regime guidelines which are protective of American eel habitat and which will ensure to the extent possible the long-term health and sustainability of the stock. States should endeavor to ensure that proposed water diversions/withdrawals from rivers tributary to important habitats will not reduce or eliminate conditions favorable to American eel which make use of these areas.

4.3.3.1 Contaminants

American eel accumulate high concentrations of contaminants, potentially causing increased incidence of reproductive impairments. In the St. Lawrence River migrating silver eel, vertebral malformations and basophilic foci (lesions) in the liver were found to be most common in contaminated eel, while nematodes were present in American eel that were less contaminated (Couillard, et. el. 1997). Another study found that the highest concentrations of chemicals were found in the gonads (Hodson et.al. 1994).

Documentation of American eel being used as an indicator species for contaminant levels could not be found. Little work has been done on the effects of pollutants and the tolerance limits of American eel (Facey and Van Den Avyle 1987). Toxicity studies of aquacultural chemicals effects on the various life stages of the American eel suggest increased tolerance with size and age (Hinton and Eversole 1978, 1979, 1980). However, an accidental release of toxins into the Rhine River in 1986 killed hundreds of thousands of European eel (Facey and Van Den Avyle 1987). American eel tend to bioaccumulate heavy metals endemic to their freshwater habitat (Moreau and Barbeau 1982). Apparently, they also bioaccumulate other toxins as well. In 1976, New York's Departments of Health and Environmental Conservation banned the sale and possession of American eel taken from Lake Ontario and the Hudson River because of excessive polychlorobiphenyls (PCB) levels (greater than the legal limit of 2 ppm). Hudson River American eel were reported to have from 50 to 75 ppm and the Lake Ontario eel had 2.5 to 4.5 ppm of PCB's (Blake 1982). American eel are apparently sensitive to hypoxia and have been reported to select waters with high oxygen tensions (Hill 1969, Sheldon 1974). Tesch (1977) wrote, " the eel survives better in air than in poorly oxygenated or polluted water." American eel are especially susceptible to the accumulation of toxic compounds because of their long residence in aquatic habitats and their accumulation of lipids prior to migration. The impact of these toxic compounds on the American eel themselves has not been studied. However, these compounds can pass through the food chain and accumulate in human and wildlife consumers of American eel where they can increase the risk of cancer or interfere with normal reproduction. Furthermore, while clearly posing some risk to all consumers, the bioaccumulation of contaminants is a particularly critical issue to subsistence users of American eel, such as Native American tribes. This is because such user groups likely consume fish at far higher rates than either recreational fishers or individuals that purchase and consume American eels from commercial sources. Clearly, maintaining good water quality is important for maintaining the health of both humans and wildlife. Federal and state fishery management agencies should take steps to limit the introduction of compounds which pose a threat to human or American eel health.

American eel from the Kennebec River (Richmond) and the Penobscot River (Bangor) have been tested for dioxin (Mower 1996), and American eel from the west branch of the Piscataqua River (Falmouth) have been tested for heavy metals, PCBs, and organochloride pesticides (Sowles et al. 1996). Dioxin levels for Kennebec River and Penobscot River eel exceeded the maximum allowable concentrations recommended by the Department of Human Service's Bureau of Health. Eel from the Piscataqua River exceeded the Bureau's recommended Fish Consumption Advisory Threshold for mercury; had the highest levels of chromium, zinc, and chlordane of all the fish collected from the site; exceeded the EPA's Risk Based Consumption Limit (RBCL) and screening value (SV) for PCBs and coPCBs; and exceeded the RBCL for DDT. The RBCL is the highest concentration that allows for unlimited consumption for the most conservative exposure scenario (e.g. children versus adults), and the SV is a recommended safe concentration based on effects to the general population of adults.

Toxicological studies have indicated the American eel in certain areas bioaccumulate polychlorinated biphenols (PCBs) in levels above the food health standard (2.0 ppm) (Sowles et al, 1997). American eel have a high fat content and a bioaccumulation of many toxins occurs in the fat of the fish. Studies have also shown bioaccumulation of mercury and other heavy metals, dioxin and chlordane at levels warranting attention in some jurisdictions. Some states have issued health advisories regarding consumption of American eel. The impact of these chemicals on the health and reproductive capacity of American eel themselves is unknown.

4.3.4 Fisheries Practices

The use of any fishing gear or practice, which is documented by management agencies to have an unacceptable impact on American eel (e.g. habitat damage, or bycatch mortality), should be prohibited within the effected important habitats.

4.4 ALTERNATIVE STATE MANAGEMENT REGIMES

With approval of the American Eel Management Board, a state may vary its regulatory specifications listed in Section 4, so long as that state can show to the Board's satisfaction that the goals and objectives of this FMP will still be met.

4.4.1 Procedures

Procedures to modify state regulations include the following:

(a) A state may submit a proposal for a change to its regulatory program or any mandatory compliance measure under the Plan to the ASMFC. Changes shall be submitted to the ASMFC staff, who will distribute the proposal to the Management Board, the Plan Review Team, the Technical Committee, the Stock Assessment Committee, and the Advisory Panel.

(b) States must submit a proposal at least two weeks prior to the Technical Committee's spring or fall meeting.

(c) The Plan Review Team is responsible for gathering the comments of the Technical Committee, the Stock Assessment Committee, and the Advisory Panel, and presenting these comments to the Management Board for action.

(d) The Management Board will approve the state proposal for an alternative management program if it determines that the alternative management program is consistent with the goals and objectives of this Plan.

4.4.2 *De minimis* Status

The ASMFC Interstate Fisheries Management Fisheries Program Charter defines *de minimis* as "a situation in which, under existing condition of the stock and scope of the fishery, conservation, and enforcement actions taken by an individual state would be expected to contribute insignificantly to a coast-wide conservation program required by a Fishery Management Plan or amendment."

Under this FMP, *de minimis* status would exempt a state from having to adopt the commercial and recreational fishery regulations for a particular life stage listed in Section 4 and any fishery-dependent monitoring elements for that life-stage listed in Section 3.4.1. States may apply for *de minimis* status for each life stage if (given the availability of data), for the preceding two years, their average commercial landings (by weight) of that life stage constitute less than one percent of coast wide commercial landings for that life stage for the same two-year period. States may petition the Board at any time for *de minimis* status, if their fishery falls below the threshold level. Once *de minimis* status is granted, designated States must submit annual reports to the Board justifying the continuance of *de minimis* status.

4.5. ADAPTIVE MANAGEMENT

Under adaptive management, the American Eel Management Board may vary the requirements specified in Sections 3 or 4 of this FMP. Such changes will be effective on January 1 (or on the first fishing day of the year), but may be put in place on an alternative date when deemed necessary by the Management Board.

Procedures to implement adaptive management are as follows:

(a) The Plan Review Team (PRT) will continually monitor the status of the fishery and the resource, and report to the Management Board on or about October 1. The PRT will consult with the Technical Committee, the Stock Assessment Committee, and the Advisory Panel, in making their review and report. The report will contain recommendations concerning proposed adaptive revisions to the management program.

(b) The Management Board will review the PRT report, and may consult independently with the Technical Committee, the Stock Assessment Committee, or the Advisory Panel. The Management Board may direct the PRT to prepare an addendum to effect changes it deems necessary. The addendum shall contain a schedule for the states to implement its provisions.

(c) The PRT will prepare a draft addendum as directed by the Management Board, and shall distribute it to all states for review and comment. The Management Board shall, in coordination with each relevant state, utilizing that state's established public review process, ensure that the public has an opportunity to review and comment upon proposed adaptive management changes. The PRT will also request comment from federal agencies and the public at large. After a 30-day review period, the PRT will summarize the comments and prepare a final version of the addendum for the Management Board.

(d) The Management Board shall review the final version of the addendum prepared by the PRT, and also shall consider the public comments received and the recommendations of the Technical Committee, the Stock Assessment Committee, and the Advisory Panel; it shall then decide whether to adopt or revise the addendum.

(e) Upon adoption of an addendum, states shall prepare plans to carry out the addendum and submit them to the Management Board for approval, according to the schedule contained in the addendum.

4.6 EMERGENCY PROCEDURES

Emergency procedures may be used by the American eel Management Board to require any emergency action that is not covered by or is an exception or change to any provision in this fishery management plan. Procedures for implementation are addressed in the ASMFC Interstate Fisheries Management Program Charter, Section 6 (c) (10) (ASMFC 1998).

4.7 MANAGEMENT INSTITUTIONS

4.7.1. Atlantic States Marine Fisheries Commission and ISFMP Policy Board

The Atlantic States Marine Fisheries Commission (Commission) and the Interstate Fisheries Management Program (ISFMP) Policy Board are responsible for the oversight and management of the Commission's fisheries management activities. The Commission must approve all fishery management plans and amendments thereto, and must make final determinations concerning state compliance or noncompliance. The ISFMP Policy Board reviews recommendations of the various Management Boards and, if it concurs, forwards them to the Commission for action.

4.7.2 American Eel Management Board

The American Eel Management Board is responsible for the development of a fishery management plan or amendment, and has voting representatives from Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Potomac River Fisheries Commission, District of Columbia, Virginia, North Carolina, South Carolina, Georgia, Florida, the USFWS, and the NMFS. The Board shall provide the ISFMP Policy Board with review and recommendations based on the fishery management plan. The Board may, after the necessary plan or amendment has been approved by the Commission, continue to monitor the implementation and enforcement of the fishery management plan or amendment, advise the ISFMP Policy Board of its effectiveness, or take other actions specified in the fishery management plan that are necessary to ensure its full and effective implementation.

The Board may directly consult with the chairs of the Technical Committee, Plan Review Team, Citizens' Advisory Panel and a representative from the ASMFC Law Enforcement Committee.

4.7.3 Plan Review Team

The Plan Review Team (PRT) is a small group whose responsibility is to provide staff support necessary to carry out and document the decisions of the Management Board. The PRT is directly responsible to the Management Board for providing information and documentation necessary to carry out the Board's decisions.

4.7.4 Technical Committee

The Technical Committee will consist of one representative from each jurisdiction and federal agency with an interest in the American eel fishery. Its role is to act as a liaison to the individual state agencies, providing information to the management process and review and recommendations concerning the management program. The Technical Committee will report to the Management Board, normally through the PRT.

4.7.5 Stock Assessment Subcommittee

The Stock Assessment Subcommittee (SASC) will consist of those scientists with expertise in stock assessment methods. Its role is to assess American eel populations and provide scientific advice concerning the implications of proposed management alternatives, or to respond to other scientific questions of the Management Board. The Stock Assessment Subcommittee membership will be proposed by the Technical Committee, and approved by the Management Board. The Stock Assessment Subcommittee will report to both the Plan Review Team and the Technical Committee.

4.7.6 Advisory Panel

The American Eel Advisory Panel is established according to the ASMFC Advisory Committee Charter. Members of the Advisory Panel are citizens who represent a cross-section of commercial and recreational fishing interests and others concerned about American eel conservation and management. The Advisory Panel provides the Management Board with advice directly concerning the Commission's American eel management program.

4.7.7 Departments of Commerce and Interior

The Commission has accorded NMFS (Department of Commerce) and the USFWS (Department of the Interior) voting status on the ISFMP Policy Board and the American Eel Management Board. These federal agencies may participate on the Plan Review Team, the Technical Committee, and the Stock Assessment Committee.

4.8 RECOMMENDATIONS TO THE SECRETARIES

Secretary of Commerce

The ASMFC recommends that the Secretary of Commerce address and initiate controls over harvest and use of American eel in federal waters (3-200 nautical miles offshore) that are not landed in states. Specifically, the ASMFC recommends that the Secretary of Commerce ban harvests of American eel at any life stage in the EEZ, but permits the possession of up to 50 eel per person as bait

Secretary of Interior

The U.S. Fish and Wildlife Service should provide an annual report, using the Service's new nationwide fish impediment database, documenting the progress made in alleviating barriers to passage for species managed by the Commission, including American eel.

In addition to existing channels for documenting exports, it is also recommended that the Secretary of the Interior proceed with listing American eel glass eel and elvers in Appendix III of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). An Appendix III listing in no manner prohibits the harvest of American eel at any life stage. The Appendix III listing would improve law enforcement and shipment monitoring of glass eel and elvers in the lucrative but largely undocumented international trade. The listing provides for monitoring and inspection at the port of departure and also at the port of arrival of the importing country through the use of a permit system. A CITES Appendix III export permit indicates that a legal harvest has taken place in accordance with the permit issuing authority.

This listing has been recommended, in part, because of discrepancies in law enforcement reports that monitored only a portion of all live eel exports. In this limited number of inspected shipments, U.S. Customs Service records showed export weights that far exceeded National Marine Fisheries Service estimates of the east coast's entire American eel harvest. These data may indicate a need for better export tracking mechanisms through CITES permitting, but do not diminish the continuing need for state and local law enforcement in the field.

5.0 COMPLIANCE

5.1 MANDATORY COMPLIANCE ELEMENTS FOR STATES

Upon completion and approval of a management plan, Commission participating jurisdictions (ME, NH, MA, RI, CT, NY, NJ, PA, DE, MD, PRFC, DC, VA, NC, SC, GA, FL) are obliged to implement its requirements, unless exempted by *de minimis* status. If a state does not comply with the conservation measures of the Commission's fishery management plan, the law allows the U.S. Secretary of Commerce to impose a moratorium on that state's particular fishery. All Commission fishery management plans must include specific measurable standards to improve the status of the stocks and to determine if the states comply with the standards.

5.1.1 Mandatory Elements of State Programs

The following lists the mandatory program elements required for all participating states/jurisdictions to remain in compliance with this Fisheries Management Plan. Details of these compliance requirements are discussed in the identified sections.

1. Annual Young-of-Year Abundance Survey (Section 3.1.1)

2. Annual State Report on Regulations, Harvest, Effort, Bycatch, and Fishery Independent Surveys for American Eel (Section 3.4.1).

3. Recreational Fisheries Management Measures (Section 4.1).

4. Commercial Fisheries Management Measures (Section 4.2).

A state will be found out of compliance if:

(a) The American Eel Management Board has not approved the regulatory and management programs for American eel.

(b) It fails to meet any implementation schedule established in this FMP or any addendum prepared under adaptive management (see Section 4.5).

(c) It fails to conduct an annual young-of-year abundance survey, unless otherwise exempted by the Management Board, beginning in the year 2000. If initially exempted states fail to conduct the young-of-year survey by the year 2001 (See Section 3.1.1).

(d) It fails to implement a change to its program when determined necessary by the American Eel Management Board.

(e) It fails to adequately enforce any aspect of its regulatory and management programs.

5.1.1.1 Regulatory Requirement

All state programs must include a regime of restrictions on recreational and commercial fisheries consistent with the requirements of Sections 4.1 and 4.2; except that a state may propose an alternative management program under Section 4.4. If approved by the American Eel Management Board, the state's proposal may be implemented as an alternative regulatory requirement for compliance under the law.

5.1.1.2 Monitoring Requirements

All state programs must include the mandatory monitoring requirements contained in Section 3.4.1 of the Plan. States must submit proposals to the Commission for any proposed changes to the required monitoring programs if the change may affect the quality of the data or the ability of the program to fulfill the needs of the fishery management plan. State proposals for modifications to required monitoring programs will be submitted to the Technical Committee at least two weeks prior to its spring or fall meetings. Proposals must be on a calendar year basis.

The Technical Committee will make recommendations to the American Eel Management Board concerning whether the proposals are consistent with the Plan.

If a state realizes it will be unable to fulfill its fishery monitoring requirements, it should immediately notify the Commission in writing. The Commission must be notified by the planned commencement date of the monitoring program.

The Commission will work with the state to develop a plan to secure funding or to plan an alternative program that will satisfy the needs outlined in this FMP (the Plan).

Each year, the ASMFC's Law Enforcement Committee (LEC) shall discuss new or chronic problems in enforcing eel regulations or prosecuting violators of these regulations. The LEC shall also make recommendations to improve enforcement and understanding of the regulations.

5.1.2 State Reporting and Compliance Schedule

Each state must submit an annual report concerning its American eel fisheries and management program on or before September 1 each year. The report shall cover:

(a) The previous calendar year's fishery and management program, including activity and results of monitoring (as identified in Section 3.4.1. of the Plan), regulations that were in effect, and harvest, including estimates of non-harvest losses and effort.

(b) The planned management program for the current calendar year (summarizing regulations that will be in effect and monitoring programs to be performed) highlighting any changes from the previous year.

States must implement this Plan according to the following schedule:

May 1, 2000: States must submit state programs to implement the Plan for approval by the Management Board. Programs, including monitoring programs, must be implemented upon approval by the Management Board.

January 1, 2001: States with approved management programs must begin implementing the Plan (or earlier if desired).

5.2 PROCEDURES FOR DETERMINING COMPLIANCE

A. The PRT will continually review the status of state implementation of the Plan, and advise the American Eel Management Board whenever a question arises concerning state compliance. The PRT will review state reports submitted under Section 5.1.2 and prepare a report for the American Eel Management Board, summarizing the status of the resource and fishery and the status of state compliance on a state-by-state basis.

B. Upon receipt of a report from the PRT, or at any time by request from a member of the American Eel Management Board, the Management Board will review the status of an individual state's compliance. If the Management Board finds that a state's regulatory and management program fails to meet the requirements of this section, it may recommend that the state is out of compliance. The recommendation must include a specific list of the state's deficiencies in implementing and enforcing the Plan and the actions that the state must take in order to come back into compliance.

C. If the American Eel Management Board recommends that a state is out of compliance, as referred to in the preceding paragraph, it shall report that recommendation to the ISFMP Policy Board for further review according to the *ASMFC Charter for the Interstate Fisheries Management Program.*

D. A state that is out of compliance or subject to a recommendation by the American Eel Management Board under the preceding subsection may request at any time that the Management Board reevaluate its program. The state shall provide a written statement concerning its actions to justify a reevaluation. The Management Board shall promptly conduct such reevaluation (e.g., within 30 days), and if it agrees with the state, the Management Board shall recommend to the ISFMP Policy Board that the determination of noncompliance be withdrawn. The ISFMP Policy Board and the Commission shall address the Management Board's recommendation according to the ASMFC Charter for the Interstate Fisheries Management Program.

6.0 INFORMATION AND RESEARCH NEEDS

6.1 MANAGEMENT AND REGULATORY

Issues that have been identified as needed to support the management of American eel (order does not indicate importance). Information needed for regulations to manage harvest, include but not limited to:

- License fees, life stage, size, geographic area, and gear type.

- Design and implement an annual, fishery-independent, glass eel abundance survey.

- Assess American eel landing records for all life stages to determine their completeness and adequacy for evaluating the eel fishery; monitor population trends; commercial and recreational harvest; and, effects of gear type on harvest rates. If necessary, determine what data are needed to improve landing records.

- Evaluate the impact of American eel aquaculture on fish health, eel culture/hatcheries, and import and/or export concerns.

- Management of the species and its harvest by non-member jurisdictions (e.g., Vermont, West Virginia, Great Lakes States, Gulf Coast States and Canada).

- Quantify and qualify the economic considerations of exporting various American eel life stages.

- Quantify and qualify the economic considerations of the American eel bait fishery.

6.2 STOCK ASSESSMENT AND POPULATION DYNAMICS

To collect information to assist in future management decisions, a comprehensive monitoring plan must be developed throughout the Atlantic Coast as described in Section 3.4. In addition to the comprehensive monitoring plan, additional stock assessment and population dynamics information should be collected to assist in future management decisions including the following:

- Conduct additional stock assessments and determine harvest mortality rates. Use these data to develop a more reliable sustainable harvest rate.

- Further evaluate life history (table) information including sex ratio and population age structure.

- Formulate a coast wide sampling program for American eel using standardized and statistically robust methodologies.

- Contaminant effects on the fishery and effects of bioaccumulation with respect to harvest and sale prohibitions.

- Size-age-sex distributions within selected drainage containing different habitat types.

- Predator-prey relations: a) food habits of American eel in various habitats and b) predation on eel.

- Movements of American eel within a drainage during the yellow eel stage: a) degree of movement of eel between fresh waters and estuaries and b) degree of movements within fresh waters.

6.3 RESEARCH

Numerous additional data needs have been identified to improve the understanding of the life history of this species and the anthropogenic stresses that may influence its health and abundance.

- Stock assessment and determination of fishing mortality rates (F) to develop a sustainable harvest rate.

- Economic studies are necessary to determine the value of the fishery and the impact of regulatory management.

- Investigate: mechanism of sex determination; growth rates for males and females throughout their range; habitat preferences of males and females; predator-prey relationships; behavior and movement of American eel during their freshwater residency; oceanic behavior, movement and spawning location of mature adult American eel; and all information on the leptocephalus stage of the American eel.

- Evaluate contaminant effects on American eel and the effects of bioaccumulation with respect to impacts by age on survival and growth and effect on maturation and reproductive success.

- Investigate mode of nutrition of American eel leptocephali in the ocean.

- Determine growth rates of male and female American eel in different habitats.

- Determine if geographic sub-populations exist, which may have implications for management.

- Investigate larval and juvenile survival and mortality to assist in the assessment of annual recruitment. Such research could be aided by continuing and initiating new tagging programs within individual states.

- Determine food habits of glass eel while at sea.

- Investigate location and triggering mechanism for metamorphosis from leptocephalus to glass eel.

- Investigate mechanisms of exit from the Sargasso Sea and of transport across the continental shelf.

- Evaluate the impact, both upstream and downstream, of barriers on American eel with respect to population and distribution affects. Determine areas of extirpation and historical distribution.

- Investigate, develop, and improve technologies for American eel passage upstream and downstream.

- Evaluate the ecosystem importance of American eels as prey, predators, and mechanisms of transporting freshwater biomass to marine systems.

- Determine fecundity-length and fecundity-weight relations for female American eel from various parts of its geographic range.

- Determine mortality rates at different life history stages (leptocephalus, glass eel, yellow eel, and silver eel) and mortality rates with size within the yellow eel stage.

- Investigate mechanism of sex determination in American eel.

- Determine age at entry of glass eel into estuaries and fresh waters.

- Investigate migratory routes and guidance mechanisms for silver eel in the ocean.

- Investigate mechanisms of recognition of the spawning area by silver eel.

- Investigate mate location in the Sargasso Sea.
- Conduct studies on spawning behavior.
- Determine gonadal development in maturation.
- Conduct workshop on aging techniques.
- Sustainable fishing mortality rates (F) for American eel have not been examined. Researchers and fishery managers have not determined the best means to ensure the stability of the American eel populations
- Identification and understanding of American eel habitat needs for all life stages
- Model the effect of increased habitat availability and reductions in mortality at various freshwater lifestages on escapement.
- Research the impacts of elver fishing on the abundance and distribution of later lifestages within a watershed and what, if any, impacts there are on sexual determination and upstream migration.
- Research techniques (physical and behavioral) for providing upstream and downstream passage around dams
- Research the feasibility and ecological/genetic impacts of trap and truck programs for elvers
- Quantify and assess male eel habitat and male eel abundance
- Quantify and estimate the impact of the bait fishery for juvenile/bootstrap eels.

7.0 PROGRAM MANAGEMENT OPTIONS

7.1 IMPROVE IMPLEMENTATION EFFECTIVENESS

This FMP outlines a number of management actions addressing American eel (Section 3.1-3.3) and its habitats (Section 3.5). Since American eel are one population, management effectiveness would increase through focused coordination and standardization of most monitoring, assessment, and restoration activities throughout its range. This centralized approach could provide leverage for funding (internal and external), prioritization of research, and a central repository of information and data.

7.1.1 New Funding Options

New, dedicated funds would improve and expedite implementation of this FMP. Recommendation by the American Eel Management Board to the ASMFC members requesting their active support is needed. The following options have been suggested:

A. Advisory Panel member recommendation for a federal "migratory fish stamp," similar to the migratory bird stamps, with the funds dedicated to habitat restoration and enhancement.

B. A current effort underway by members of the hydropower industry to obtain funds from Congress to target multi-year American eel research and management enhancement.

C. Improve coordination and partnerships with other agencies with complementary missions, such as USEPA and the USACOE, to assess the ecological health of coastal watersheds and to restore them.

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9.0 APPENDIX

ATTACHMENT 1: NMFS Commerical Landing for American Eel (pounds) for the Atlantic and gulf Coasts of the U.S. by jurisdiction (Personal Communication from the NMFS, Fisheries Statistics and Economics Division, 11-15-99).

State/Province	1950 - 1996 Total pounds	Percent of total	1987 - 1996 Total pounds	Percent of total
Virginia	21228939	26.01	4087675	29.93
Maryland	12021898	14.73	1975350	14.46
P.R.F.C.	9666343	11.84	2457555	18.00
North Carolina	8102355	9.93	859843	6.30
New Jersey	7313446	8.96	1855346	13.59
New York	7088810	8.68	344310	2.52
Delaware	3798000	4.65	1398200	10.24
Massachusetts	3580451	4.39	195251	1.43
Florida East Coast	3080542	3.77	6685	0.05
Maine	2318655	2.84	259971	1.90
Connecticut	949058	1.16	165758	1.21
Rhode Island	912300	1.12	6900	0.05
South Carolina	600200	0.74	0	0.00
Florida Inland Lakes	355400	0.44	0	0.00
Georgia	250436	0.31	9048	0.07
New Hampshire	206237	0.25	2379	0.02
Florida West Coast	108508	0.13	32188	0.24
Louisiana	50614	0.06	0	0.00
Texas	98	0.00	98	0.00
Total	81632290	100	13656557	100

(Babb 1999)

V-520

Fishing report: River striped bass rebound

Web posted Friday, April 16, 1999

By Bill Babb
Outdoor Editor

Most fishermen know about the ban against catching and keeping striped bass and hybrid bass from the Savannah River below the New Savannah Bluff Lock and Dam.

The key to that section of the river being reopened for catching and keeping the fish is the number of brood fish in the total population. These are the hen fish capable of spawning.

That number dropped to next to nothing more than a decade ago and the Georgia Wildlife Resources Division, in cooperation with the University of Georgia Fisheries Co-Op, has been conducting a restocking program ever since.

The program is working: check out Bob Baurle's report and see the striper catches made by Tommy Lykins. Baurle said the fisherman released each of those whoppers.

Fishermen tempted to keep stripers should be forewarned: if Georgia Wildlife Resources Division conservation rangers find anglers with such ``evidence,'' they would have faced a hefty fine and, even worse, could lose their fishing privileges for a year or more.

So the best thing striper fishermen can do is just grit their teeth and keep to the catch-and-release program. It would be even better for them not to fish for the stripers because the fish get stressed after being hooked.

As soon as the brood fish buildup reaches numbers deemed necessary, the lower river will be opened to striper and hybrid fishing once again. Creel limits may be lower than Thurmond Lake's (10), but at least anglers will have a shot at catching a trophy striper.

STROM THURMOND LAKE

Jim Ware, U.S. Coast Guard-licensed professional fishing guide specializing in hybrids and striped bass, Plum Branch Yacht Club, Plum Branch, S.C. (1 (864) 443-5399) -- Clark and Judy Sharpe of Atlanta fished with me last Friday and we caught 15 fish. Jesse, Mark, Dale and Donnie from Mele's Shop in Abbeville fished with me on Wednesday and we caught 34 fish up to 8 pounds. Clayton DeLaigle of Swainsboro, Ga., fished with me on Thursday and caught 17 before the winds blew us off the lake. We're fishing on the bottom in 30 feet.

Soap Creek Lodge, Lincolnton, Ga. (Toye & Sue Hill, 1-706-359-3124) -- Roy Mills and family from Hephzibah caught limits of good crappies last weekend. Woodrow Sellers and his wife caught limits of largemouth on the watermelon seed worms on a foot to foot and a half leader in backs of coves. David and Elizabeth Duffy of Augusta also were making their usual good catches of crappies. Calvin Goodman of Tennessee have been camping with us and catching largemouth bass on floating and other plastic worms.

Raysville Marina, near Thomson, Ga. (Doug Pentecost, Leon Buffington, 1-706-595-5582) -- Shannon Blanch, Jonathan Goodman and Kimberly Wright caught a 52-pound flathead catfish on a trotline baited with minnows. Ed Rutherford and Bob Fultz of Ashland, Ky., caught a 7-pound largemouth bass and nine others weighing 2 to 4 pounds. We are now selling gasoline.

David Willard, Little River Marina, U.S. Coast Guard-licensed professional fishing guide specializing in hybrids and stripers. (1 (803) 637-6379) -- Fishing moved up another notch this week with some 70-degree water temperatures. I'm catching fish from the shallows early to 24 to 30 feet later in the day. Gary Hill with Advanced Air Technologies of Augusta treated friends Bob and Travis from Virginia to some striper fishing. They caught striped bass up to 13 pounds and hybrids up to 6. Phillip Nicodemus of Evans, and visiting friend Chris Black from Fort Wayne, Ind., had a great afternoon on the water, catching hybrids and stripers up to 9 pounds. It was nice of Phil to let his friend catch the largest and most fish. Chris learned an important lesson: when you go fishing in the South, bring a large cooler. Jamie and Joey Dickerson and D.G. (Skippy) Tripplett of Savannah have been camping with friends on Thurmond Lake. There's always a fishing contest and they always lose. This year, they decided to change their strategy. They slipped out of camp under cover of darkness and boated 26 stripers and hybrids and released some more. There was no mention of guides being against the rules, but there probably will be next year.

SAVANNAH RIVER

New Savannah Bluff Lock & Dam

Lock and Dam Bait and Tackle (Bob Baurle), 1-706-793-8053 - - William J. Lee caught 25 redbreasts on crickets and wax worms Friday fishing off the platform at the dam. Tommy Lykins Jr., caught and released striped bass weighing 15 and 20 pounds. On another trip Thursday, he caught and released a 35-pounder. Shad are socking the Fish Skin Jig Rig, which is equipped with six hooks. Sgt.-Maj. Mike Mooney and I went down river on Wednesday and caught 20-something nice bream.

Fishermen are reminded striped bass and hybrid bass cannot be lawfully caught and kept from the river's mouth at Savannah to the New Savannah Bluff Lock and Dam. The moratorium is in effect until at least the year 2000.

MERRY BROTHERS BRICKYARD PONDS

Bill Gibson 1 (706) 722-2980 -- Steve Hendren caught five bass weighing 15 1/4 pounds to win last Friday's tournament. His big fish weighed 6 1/2 pounds. Hendren and Jay Dilorenzo fished last Tuesday and caught 10 bass ranging from 1 3/4 to 3 pounds in the Ditch with plastic worms. A few shellcrackers have been caught.

We're holding a bass team tournament running from 6 p.m. to 10 p.m., today. Entry fee is $20 per person and bass must be 12 inches or better.

FAY & JOANN'S LAKES

(706) 722-8263 -- Jerome Sessions caught three 6-pound channel catfish on shrimp. Tim Cox caught a 10-pound catfish and three 5-pounders on shrimp. Tim Cox II caught catfish weighing 8 and 3 1/2 pounds on shrimp. Arteming Bayat caught a 13 1/2 -pound channel catfish and a couple of 2-pounders on shrimp. Bobby McRae caught seven 5 pounds or better blue catfish, one 2-pound blue and one 2-pound channel catfish on nightcrawlers. Gary Barton caught a 10-pound catfish on small minnows and three smaller ones on worms. Kenny McBride caught 40 shellcrackers on red worms. Jim Jewell caught 17 shellcrackers on red worms. James Green caught 21 shellcrackers on red worms. Fay Stringfellow caught 19 shellcrackers on red worms. Cara Parker caught channel catfish weighing 16 and 8 pounds on chicken liver. Carl Smith caught 14 catfish 2 pounds or better on red worms and 16 shellcrackers on red worms.

ATLANTIC OCEAN

BEAUFORT, S.C. & VICINITY

Includes Paradise Pier

Joe Mix, Island Outfitters, Ladys Island, 1-(843)-522-9900 -- Except for whiting and flounder, inshore fishing slowed down this week. Water temperatures have risen to 68 degrees and sharks are beginning to show up in St. Helena and Port Royal sounds. Loggerhead turtles have also begun to show up and will begin nesting on barrier island beaches in early May.

Offshore action also was slow, but charter captains report sighting migrating schools of herring which usually means that cobia aren't far behind. Anglers will experience higher than normal tides this weekend, peaking at 9 feet on Saturday afternoon.

SAVANNAH AREA

Miss Judy Charters, Capt. Judy Helmey, 912-897-4921. Inshore, trout, spottail bass, whiting and flounder are being caught from the creeks to the sound. Live shrimp fished beneath floats or on the bottom will work.

Offshore, large back sea bass are still holding on artificial reefs, with squid the No. 1 bait. The Savannah Snapper Banks have finally turned on, with red snapper and grouper hitting squid and live fish.

Bottom fishing also is great at the Gulf Stream, with cigar minnows and squid the best bait. Trolling will catch dolphin, tuna and wahoo in 160 to 250 feet of water.

Bill Babb covers the outdoors for *The Augusta Chronicle*. He can be reached at 1 (706) 823-3304.

[Past Articles]

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V-521

River the new hot spot for bass

Bass 2005

River the new hot spot for bass

By Bill Baab | *Fishing Editor*

Friday, June 17, 2005

When Thurmond Lake's fish turn off so you can't buy a strike over two mornings of fishing, what's a fisherman to do?

"Take me to the river," warbles the electronic toy Billy Bass, and that's a great idea.

The Savannah River below the New Savannah Bluff Lock and Dam is literally loaded with fish at this time of the year, as fishing buddies Ralph Barbee Jr., and Pete Glabas learned Wednesday morning.

Accompanied by Pete's son, Tyler, they cast a mullet look-a-like lure into the river below the dam and caught two monster striped bass. Glabas' fish hit the 50-pound mark on the scales, while Barbee's weighed 40 pounds.

This is strictly a catch-and-release thing, and has been since a moratorium on catching and keeping was placed on the river from the lock and dam to its mouth at Savannah in 1989. Fishermen might be allowed to keep a limited number of hybrid and striped bass from that area later this year if the Georgia and South Carolina Departments of Natural Resources can get together. An announcement is expected sometime in October.

So after taking pictures, the two monster stripers were released.

"We had five strikes altogether with two fish breaking free and the third making off with my lure when my reel backlashed," Barbee said. "This is an early morning bite that's over once the sun rises above the treeline. If it's foggy, as it was on Wednesday, so much the better, but you've got to be careful moving up the river from the boat ramp."

Bob Baurle, a veteran river fisherman who operates Lock and Dam, Bait & Tackle, said the stripers and hybrids also are hitting two or three hours before dark.

"They're not all big fish - some are 3 and 4 pounds, or 8 to 12 pounds," he added.

Special

Tyler Glabas, of Martinez, helps Ralph Barbee Jr., of Evans, show off his 40-pound striped bass caught Wednesday morning in the Savannah River.

Special

Tyler Glabas, of Martinez, and his father, Pete, who landed a 50-pounder below New Savannah Bluff Lock and Dam.

STROM THURMOND LAKE

Capt. David Willard, U.S. Coast Guard-licensed full-time professional fishing guide specializing in hybrids and stripers and trophy largemouth bass. Box 131, Clarks Hill, SC 29821 (803) 637-6379 (crockettrocketstriperfishing.com) - We're on the back side of a spring-summer transition that has seen the fish really scattered. Cooler than normal spring temperatures plus high water levels have kept the lake from stratifying. The dissolved oxygen levels also are good at all depths, so the fish can be anywhere. The last few days of hot weather have started to group the fish up and we saw evidence this (Thursday) morning. We had huge schools of fish beneath the boat, and could catch only one or two before they left. Brad Bailey with Georgia Outdoor News fished with me and my two girls, Jesse and Sarah, on Tuesday. I told him fishing was tough, but we decided to go anyway. I told the girls we wouldn't have a whole lot of hits so don't miss any strikes. They did really good, paying attention, not snacking and hooking up every fish that struck. Bill Colbert from Evans fished with his son, Todd, who is attending Southeastern Baptist Theological Seminary in Wake Forest, N.C. You could tell he stood in good with the Lord because we had good schools of fish beneath the boat all morning. They ended up with a dozen nice hybrids. We fished in water 24 to 30 feet deep.

Ralph Barbee, professional guide, (706) 860-7373, 957 Windmill Lane, Evans, GA. 30809 - I fished Thurmond Lake on Monday and Tuesday and never caught a fish. I cast the Pencil Popper, Hub's Chub, Super Fluke and crank baits around points and over humps and never had a strike. Then I heard about a 40-pound striped bass being caught in the Savannah River below the lock and dam. So Pete Glabas and his son, Tyler, and I fished there early Wednesday morning. We had five strikes and caught just two fish. Pete's striper weighed 50 pounds, while I landed a 40-pounder. Both fish were released after having their pictures taken. Two of the other fish pulled free, while a third took off with my mullet-like plug after my reel backlashed. I'd be willing to swear that fish weighed more than 60 pounds. You can see 'em in that clear water. The fishing is over after the sun clears the trees, so you've got to be on the water well before daylight.

My fishing show features Jim Murphy, Pete Glabas and I catching largemouth, hybrid and striped bass on Thurmond Lake using the modified Pencil Popper. There's exciting action, plus my frustration shows when I lose a 40-pound-class striper. The show runs Saturday at 11 a.m., on UPN Augusta and

Sunday at 2 p.m. on UPN Augusta, including Knology Ch. 7, Comcast Ch. 21, Charter Ch. 9 (Fort Gordon), G Force (Aiken) Ch. 7, Northland (Burke County, Statesboro, Swainsboro) Ch. 9 on Sundays from 2-2:30 p.m.

Ron Figueroa, professional guide specializing in largemouth bass, hybrid bass, (706) 832-7230 (ronfig@comcast.net or his web site at buckeyelures.com/figs) - I fished Tuesday with Nat Hodges of Ormond Beach, Fla., a Shimano fishing tackle representative who was passing through from Atlanta on his way to Savannah. We eased into Trade Winds Marina and pitched a Super Spook Jr., around the docks from sunrise 'til 9 a.m. He caught two over 4 pounds. We wound up with 13 nice-sized fish 3 to 4 pounds.

Billy Murphy, professional guide, (706) 733-0124 (web site doubletroublefishingguides. com) with twins Brad and Jim) - Westside coach Doug Holland and I fished on Thursday morning in the Indian Cove-Cherokee Creek area. The fish were scattered and we wound up with eight hybrids, fishing 30 to 35 feet deep in 50 to 78 feet of water. The biggest fish weighed 7 pounds, the rest 3 to 5 pounds.

Craig Johnson, professional guide specializing in largemouth bass, hybrid bass, striped bass. (706) 564-9564 - Fishing has fallen off at Thurmond Lake this week, but we were able to boat a limit of bass with the biggest going 4 pounds. The best bait again was Buckeye's 5/16th-ounce Spot Remover rigged with a black/blue swirl Yum Dinger fished on humps in the Savannah River arm of the lake. The bass have moved into deeper water, and I'm catching fish between 12 and 21 feet of water. No hybrids or stripers were caught. I fished the Savannah River below the lock and dam on Monday and caught some nice largemouths between 2 and 4 pounds on the quarter-ounce Spot Remover rigged with a Zoom green pumpkin Speed Worm. I fished the laydowns and current breaks behind the wing dams (pilings) in two to six feet of water. Hybrids and stripers were schooling when I got there, but you have to be there early to catch them. They stayed up only a few minutes and I never brought one to the boat. I did hang two BIG stripers, but never was able to stop them because of the current. Don't forget to tune in to my Outdoor Destinations show each Sunday on UPN Augusta at 1:30 p.m.

SAVANNAH RIVER

New Savannah Bluff Lock & Dam

Lock and Dam Bait and Tackle (Bob Baurle), (706) 793-8053.- They're catching lots of redbreasts down river in the eddys and cuts on crickets and wax worms. Catfish and shellcrackers are hitting a new green nightcrawler I've been stocking. Tim Williams has been fishing Butler's Creek behind the Mayor's Fishin' Hole and catching lots of fish, while they're tearing up stripers and hybrids, releasing all of them, as well as mullet, too, in the main river. Some shad also are still being caught, even though it's late in the year for that fish. It's just a great time to be on the river.

MERRY BROS. BRICKYARD PONDS

Harrison Sears (706) 722-8263 (www.brickyardponds.com) - Brian Walker caught four bass weighing a total of 9.9 pounds in the Ditch on a Super Fluke. Johnny and little Johnny Malpass caught 68 bream in the Swan Pond. Joey Moore is our big fish holder for the month with a bass weighing 7.41 pounds. It was caught in the Warren Pond on a plastic worm. Twenty-eight people fished our bass tournament last Friday. J.C. Dicks and J.J. Dixon were the winners with 7.12 pounds. James Maruca and Marty Pearson were second with 5.68 pounds. Gene Fallaw and Tom Usry caught the big bass of 4.53 pounds. Our bass tournament will be held today, weather permitting, starting at 6 p.m., with a $20 entry fee. Weigh-in is at 10 p.m.

ATLANTIC OCEAN

Beaufort, S.C. & Vicinity

Ralph Goodison, Fripp Island, (843) 838-2530, and Doug Gertis, professional guide, (843) 524-5250) - Goodison: Fishermen have been catching some nice-sized trout on live shrimp fished around the rocks at the north and south ends of Fripp Island, and in Trenchard's Inlet. Cobia fishing is red hot, with fish being caught around the Cobia Hole in the Broad River as well as bottom fishing around the Betsy Ross wreck. King mackerel are starting to show up, but so are barracudas. If you hook a king, you've got to reel fast to get it in because the 'cuda will attack and leave you with half-a-fish or less. Offshore bottom fishing in 100 feet of water over reefs is netting some fine red and vermilion snappers, big black sea bass and an occasional grouper. Light tackle enthusiasts are catching Spanish mackerel off Bay Point as well as right in front of Fripp. Spadefish have been showing up around the sea buoys, but there haven't been many jellyballs seen. Spadefish can be caught on the jellyballs.

specialAt right, , then joins

From the Friday, June 17, 2005 printed edition of the Augusta Chronicle

Bailey, et al. 2004

Transactions of the American Fisheries Society 133:300–308, 2004

Movement and Population Size of American Shad near a Low-Head Lock and Dam

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Y-478

Abstract.—We investigated the population size and the proportion of the population of American shad *Alosa sapidissima* that passed through the New Savannah Bluff Lock and Dam, a low-head lock and dam on the Savannah River in South Carolina and Georgia. We fitted 110 American shad with radio transmitters in 2001 and 2002. All but two fish moved downstream after transmitter implantation. In 2001, a smaller proportion of American shad implanted with radio transmitters earlier in the season returned to the dam than fish released later. Of the fish that returned to the dam, over 50% in 2001 and 9% in 2002 passed through the lock and continued migrating upstream. In both years, the modal daily movement distance was less than 1 km. Movements greater than 5 km/d were generally associated with fish rapidly returning upstream after their initial downstream movement. Continuous diel monitoring indicated that movements greater than 0.1 km/h were more frequent at night than during the day. In both years, American shad were not uniformly distributed over the study area but were predominantly grouped just below the dam and in a relatively large pool approximately 6 km below the dam. We estimated the population size of American shad that reached the New Savannah Bluff Lock and Dam at 157,685 in 2001 and 217,077 in 2002.

The American shad *Alosa sapidissima* is an anadromous clupeid native to the East Coast of North America from the St. Johns River, Florida, to the St. Lawrence River, Canada (Liem 1924; Bigelow and Schroeder 1953). The timing of the spring spawning migration varies with latitude (Leggett and Whitney 1972) and is closely linked to temperature. American shad may enter their natal streams once the water temperature rises above 4°C; however, spawning activity is greatest between 14°C and 21°C (Walburg and Nichols 1967; Leggett and Whitney 1972).

Since the late 1800s, a suite of factors has caused a decline in anadromous stocks in the genus *Alosa* along the East Coast. Most markedly, the construction of dams has greatly reduced the number of spawning and nursery grounds (Rulifson 1994). Although some fishways were constructed when dams were built, most were not effective (Stevenson 1899). Navigation locks have been considered alternatives to fishways, although their effectiveness has generally not been assessed (Nichols and Louder 1970). Passage efficiency for American shad through a low-head lock varied from 15% to 50% over a 3-year period (Moser et al. 2000). Other migratory species show similar low and variable passage rates through lock systems (Chappelear and Cooke 1994; Pegg et al. 1997).

Passage may be related to retention time in the vicinity of the passage facility (Barry and Kynard 1986). Retention time of American shad has not been closely studied, but other migrating fish species have exhibited large variation in the time spent in a tailrace prior to passage or out-migration (Chappelear and Cooke 1994; Pegg et al. 1997). Nocturnal fallback—the temporary out-migration of fish encountering a barrier after sunset—has been documented (Barry and Kynard 1986). High diel variation in movement, passage, and velocity preference has also been observed (Theiss 1997; Moser et al. 2000).

The objective of this study was to examine the

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channel into two smaller channels. The larger, deeper channel leads directly to the lock entrance. American shad follow the main river channel during migration, often using the lower one-third of the water column (Witherell and Kynard 1990). Barry and Kynard (1986) found that turbulent flows could confuse and deter fish from an area. The turbulent flow within 30 m of the dam may have caused fish to repeatedly move downstream and upstream, increasing the time spent in the main channel. This orientation could lead to a higher probability of encountering the lock entrance and passing upstream.

In both years, the population size of American shad reaching NSBLD was similar. The population estimates for either year are similar to the Altamaha River system (D. Harrison, Georgia Department of Natural Resources, personal communication). Numbers of American shad reaching NSBLD were similar to the observed numbers at a fish lift in South Carolina (Cooke and Leach 2002); however, those values are highly variable and were assessed by numbers of fish that successfully pass through the lock. Mark-recapture studies on migrating fish are inherently difficult because of high interannual variation, difficulties in capture, and potential biases. Most mark-recapture studies are conducted in cooperation with commercial gill-net fisheries, and often assess all fish that enter rivers, not only those that reach spawning grounds. Mark-recapture studies, in conjunction with telemetry, are valuable to the assessment of differential movement and may provide more realistic estimates of populations.

Acknowledgments

This study was funded through grants from the U.S. Fish and Wildlife Service, South Carolina Department of Natural Resources, and the South Carolina Cooperative Fish and Wildlife Research Unit. We thank the U.S. Army Corps of Engineers for providing access to the facility. Cooperating agencies for the South Carolina Cooperative Fish and Wildlife Research Unit are the U.S. Geological Survey, Clemson University, the South Carolina Department of Natural Resources, and the Wildlife Management Institute.

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Barrt 2000

ordeal. The objective of this study was to determine the effect of angling time on blood pH, HCO_3 -, pCO_2, TCO_2, pO_2, and O_2 saturation. A secondary objective was to monitor mortality of the fish angled at 0-0.5, 1, 2, 3, 4, and 5 min. The effect of temperature (26_C, 8_C) on the stress response and acute mortality was also examined. There was a significant effect ($P<0.05$) of angling time on acute mortality and the blood parameters, with the exception of oxygen values. As playing time increased, trends in blood parameters indicated both a respiratory and metabolic acidosis. Higher temperatures resulted in significantly lower blood pH, HCO_3 -, TCO_2, pO_2, and O_2 saturation values, indicating a more severe metabolic acidosis than fish caught in the winter.. However, fish caught in the winter had a more severe respiratory acidosis.

Key words: respiratory acidosis, metabolic acidosis, striped bass, mortality, catch and release

Habitat Utilization by Striped Bass in J. Strom Thurmond Reservoir During the Summer

Shawn Young, and J. Jeffery Isely; SC Cooperative Fish and Wildlife Research Unit, Dept of Aquaculture, Fisheries and Wildlife, Clemson University, SC 29631-0372 (864-656-5335) shawny@clemson.edu

C. Wade Bales; SC Dept of Natural Resources, PO Drawer 1040, Abbeville, SC 29620 (864-223-2008)

A radio telemetry study is currently being conducted to record the summer and seasonal habitat use of adult striped bass *Morone saxatilis* in J. Strom Thurmond Reservoir, and to relate actual habitat use to available habitat. Thurmond Reservoir is a 28,329-ha impoundment on the Savannah River that undergoes thermal stratification. This will provide a baseline index of available and utilized striped bass habitat prior to modification of the thermal and dissolved oxygen levels greater than 2 mg/L is a potential limiting factor in populations of striped bass. During spring and early summer of 1999, a total of 34 adult striped bass (>3 kg) were surgically implanted with temperature-sensing radio transmitters. A systematic tracking survey of individual fish locations was conducted at least twice a month from May to October. At each location, GPS position, fish body, and a temperature and dissolved oxygen profile of the water column were. Striped bass made large scale (>10 km) movements in response to changes in temperature and oxygen. Preliminary results show adult striped bass distribution and movement in J. Strom Thurmond Reservoir is affected by changing temperature and dissolved oxygen levels during the summer.

History of the Robust Redhorse in the Savannah River

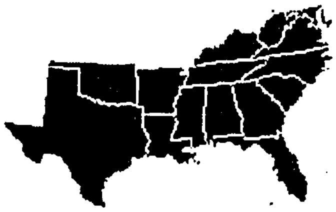
Tim Barret; GA Dept of Natural Resources; 22814 Highway 144, Richmond Hill, GA 31324; (912)727-2112.

The robust redhorse *(Moxostoma robustum)*, a large riverine catostomid first described in 1869, remained largely unknown to science until the discovery of a population in the Oconee River, Georgia in 1991. Although historical records suggested that the species once inhabited medium to large rivers along the lower Atlantic slope, the existence of a population in the Savannah River was not clearly documented until 1997. Large scale sampling efforts have now yielded a total of 31 adult robust redhorse from the upper coastal plain and Augusta Shoals area of the Savannah River. Efforts to recover the robust redhorse were initiated in 1992 and the Robust Redhorse Conservation Committee was established in 1995 by a Memorandum of Understanding among a diverse group of stakeholders, including state and federal agencies, power companies, and conservation groups. These efforts were extended to the Savannah River Basin in 1995 when fingerlings were introduced into the upper Broad River Basin. Broodfish obtained from the Savannah River were first spawned in 1999. It is anticipated that the Savannah River will continue to be a focus of ongoing conservation efforts for the robust redhorse.

Effects of Watershed and Stream Habitat Conditions on Fish Communities in the Upper Roanoke River Watershed, Virginia

Vann F. Stancil and Donald J. Orth; Dept of Fisheries and Wildlife Sciences, Virginia Tech Cheatham Hall, Blacksburg, VA 24061-0321 540-231-5320 vstancil 2vt.edu

Fish communities are impacted as urbanization continues to alter landscapes. Our study compared fish communities in watersheds of varying degrees of urbanization to determine ways to mitigate impacts and direct future development scenarios. We sampled 43 sites in the upper Roanoke River watershed, Virginia during late Spring and Summer of 1998 and 1999. Using one pass backpack electrofishing, we sampled 22 small, 13 medium, and 8 large stream sites with average stream widths from 2.8 to 11.0 m. Stream habitat variables included depth, substrate size, habitat type, and canopy closure while watershed land use conditions were categorized as forest, agriculture, and low or high intensity development. We compared fish community attributes using metrics for Index of Biotic Integrity (IBI) applications to stream habitat and watershed land use variables at three spatial scales. We collected 49 species from 9 families totaling 54,809 individuals.



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James L. Oliver

SRO-NERP-12

(Bennett and McFarlane 1983)

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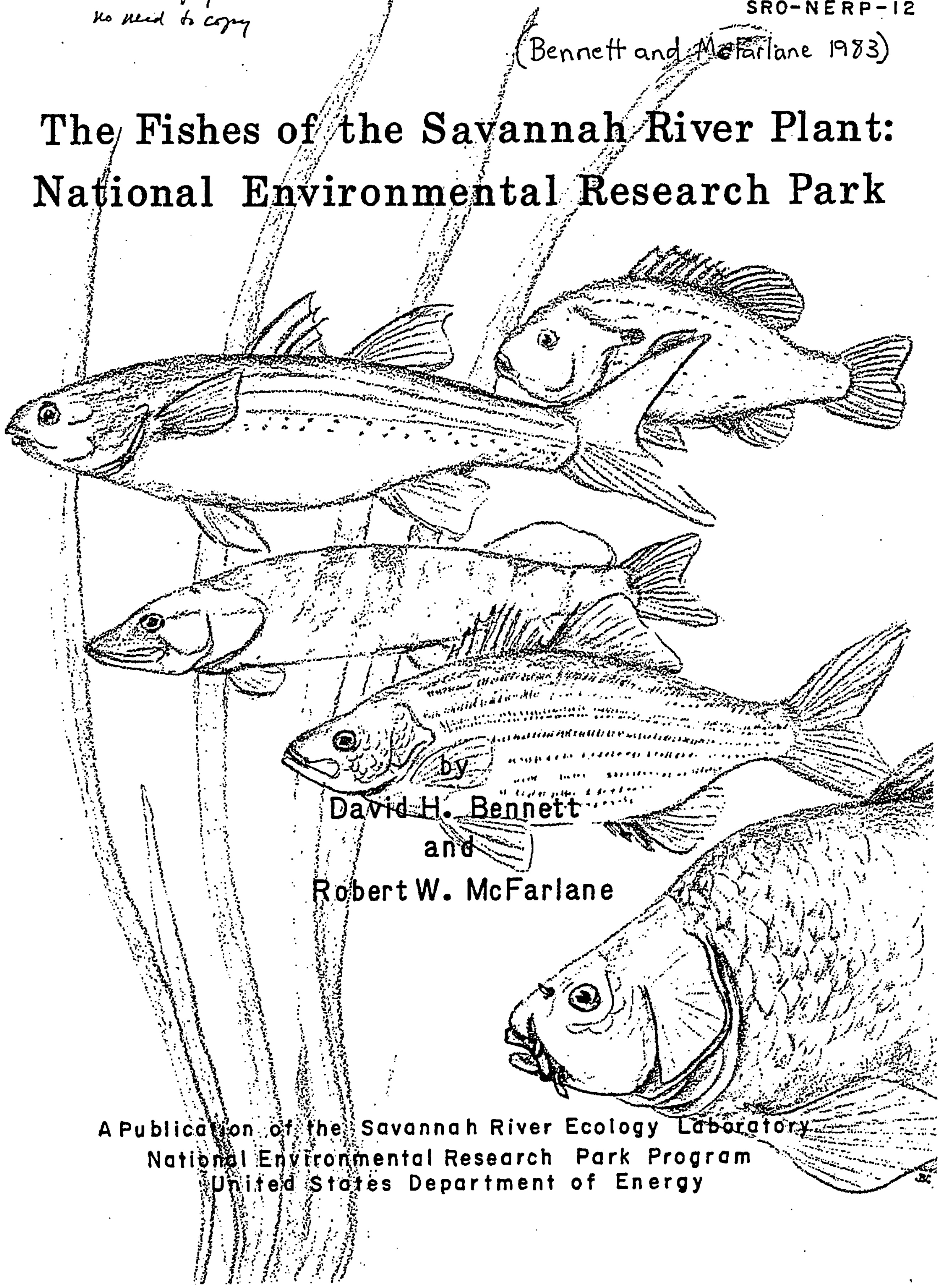
The Fishes of the Savannah River Plant: National Environmental Research Park



by
David H. Bennett
and
Robert W. McFarlane

A Publication of the Savannah River Ecology Laboratory
National Environmental Research Park Program
United States Department of Energy

THE FISHES OF THE SAVANNAH RIVER PLANT: James L. Oliver

NATIONAL ENVIRONMENTAL RESEARCH PARK

by

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Characteristics of the Adult Segment of the Savannah River Population of Shortnose Sturgeon[1]

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Abstract: During 1984–1992, 626 adult shortnose sturgeon (3.5 male:1 female) were captured in the Savannah River. Significantly more fish were captured in the lower (rkm 42–75) than the upper (rkm 160–299) river. ~~Radio telemetry data indicated that spawning appeared to occur upriver, between rkm 179 and rkm 229, and that the specific location and time of spawning varied annually.~~ Some individuals spawned in consecutive years, but others apparently did not. Nonspawning fish appeared to remain in the vicinity of the fresh/brackish water interface (ca. rkm 30–40) throughout the spawning season. Most shortnose sturgeon left the freshwater reaches of the river in Spring soon after the spawning season (January–April) and probably did not return until late Autumn/early Winter, just prior to the spawning season.

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The shortnose sturgeon, *Acipenser brevirostrum*, inhabits large coastal rivers from New Brunswick, Canada, to northern Florida (Vladykov and Greeley 1963). Prior to 1973 this species was harvested concurrently with, and not distinguished from, Atlantic sturgeon (*A. oxyrinchus*). Today it is listed as an endangered species in the United States, but recent undercover law enforcement work indicates that it is still illicitly taken for its flesh and eggs (caviar).

The biology of shortnose sturgeon in the northern portion of its range has been the focus of several studies (Dadswell 1979, Taubert 1980, Buckley and Kynard 1985), but relatively little information is available concerning the biology

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of this species in southern rivers. During 1984–1992 the South Carolina Wildlife and Marine Resources Department (now the S. C. Department of Natural Resources) and the United States Fish and Wildlife Service conducted a cooperative study of shortnose sturgeon in the Savannah River. This paper reports on various aspects of the biology of adult shortnose sturgeon inhabiting the Savannah River.

We gratefully acknowledge the assistance of Elizabeth Kennedy, Charles Bridgham, and Allan Hazel in data collection. We also appreciate the comments of William Roumillat and an anonymous reviewer.

Methods

The Savannah River was selected as the study site based on reports of incidental captures of adult shortnose sturgeon in the shad gill net fishery. This river delineates much of the South Carolina-Georgia border and flows into the Atlantic Ocean near the city of Savannah, Georgia. The river is impounded at several sites, and the present study was conducted in the ca. 300 km between the mouth and first obstruction, the New Savannah Dam near Augusta, Georgia. The upper river area (URA; river kilometers (rkm) 160–299) is relatively undeveloped with the exception of 2 major nuclear facilities; the Savannah River Site in South Carolina and Plant Vogle in Georgia. The lower river area (LRA; rkm 42–75) is similarly undeveloped, but it is just upriver from the heavily industrialized port and harbor area of the city of Savannah.

Adult shortnose sturgeon (defined as ≥56 cm total length (TL) based on examination of broodstock) were collected during 1984–1992 from the study area by

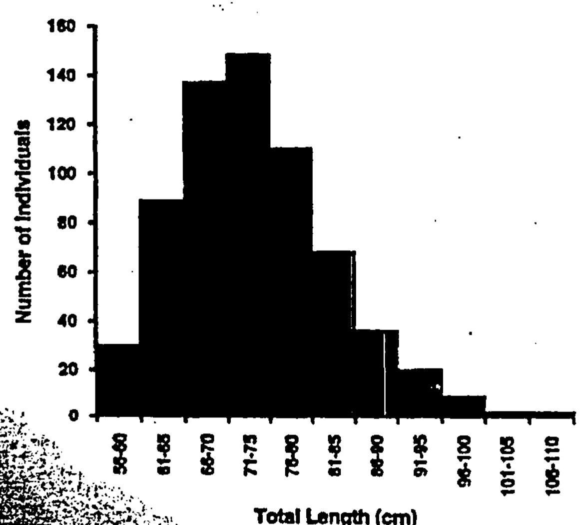

Figure 1. Length frequency of Savannah River shortnose sturgeon captured in gill nets during 1984–1992.

2 commercial shad fishermen. During the legal shad season (typically mid-January to mid-April), 1 individual fished the URA while the other fished the LRA. Fishing effort was similar in all years except 1984, when the LRA was not fished, and 1992, when only minimal effort was expended in the URA. Both fishermen used anchored monofilament gill nets of 14 cm stretch mesh. Nets were checked daily, and all sturgeon were placed in floating, cylindrical pens of plastic mesh. Project personnel removed captured sturgeon from the pens 1 to several times per week, depending on catch rates.

The captured fish were used for a variety of purposes. Many shortnose sturgeon, especially suspected ripe or nearly ripe individuals, were transported to Orangeburg National Fish Hatchery for spawning as part of a stock enhancement program (Smith et al. 1985, 1995). After 1–3 months, these fish were tagged and released into the Savannah River. Prior to 1991 fish were classified as ripe based on degree of abdominal distention, if gametes could be easily expressed, or if the vent was obviously everted. During 1991–1992 gonadal tissue acquired through biopsy was examined grossly and/or microscopically to determine stage of ripeness. Shortnose sturgeon not used as broodstock and some incidentally caught Atlantic sturgeon were marked with one or more tag types and released. When possible these fish were assigned a sex and maturity stage. Data on sex ratios and numbers of fish captured were statistically analyzed using the Chi-square test with $P < .05$ required for significance.

In order to identify spawning areas and other critically important habitats, some shortnose sturgeon were utilized in radio telemetry studies during 1990–1992. Transmitters were 70 mm long × 18 mm diameter and operated in the 48–50 Mhz range. Transmitter lifespan was estimated by the manufacturer to be 475 days. The transmitters were surgically implanted into the abdominal cavity through a ventral,

Table 1. Number of Savannah River shortnose sturgeon captured in lower (RKM 42–75) and upper (RKM 160–299) river areas by commercial shad fishermen from 15 January–15 April 1986–1992 and percentage of sexed fish that were spawning condition (running ripe and or evidence of protruding vent during 1986–1990, and examination of gonadal tissue during 1991–1992). Total number includes fish of unknown sex and maturity stage. Maturity stages were not recorded in 1984 and 1985.

	Lower river					Upper river				
	Total	Females		Males		Total	Females		Males	
Year	*N* fish	*N*	% Ripe	*N*	% Ripe	*N* fish	*N*	% Ripe	*N*	%Ripe
1984	—	—	—	—	—	25	3	—	22	—
1985	49	6	—	43	—	62	15	—	47	—
1986	36	5	40	31	50	11	1	100	10	40
1987	31	7	100	21	10	27	5	100	21	19
1988	53	13	23	31	23	29	8	75	21	67
1989	54	2	50	46	37	40	9	78	30	40
1990	55	5	60	20	25	34	7	71	26	50
1991	99	16	63	22	100	16	2	100	13	100
1992	35	15	47	6	100	1	0	0	1	100

Table 2. Size (total length), site (river kilometer) and date of release, and site and date of the relocation farthest upriver for Savannah River shortnose sturgeon tracked by radio telemetery during 1990–1992; 5 additional individuals were not relocated after the day of release.

Release			Relocation	
TL (cm)	Date	Site (rkm)	Date	Site rkm)
84.0	02 Mar 90	46.1	13 Apr 90	46.8
78.0	15 Mar 90	46.1	29 Mar 90	50.0
80.0	20 Mar 90	46.1	13 Apr 90	218.8
76.8	20 Mar 90	46.1	23 Mar 90	46.1
89.5	20 Mar 90	46.1	21 Mar 90	36.0
106.2	22 Jan 91	46.1	28 Jan 91	227.9
85.5	22 Jan 91	46.1	21 Feb 91	221.6
97.0	22 Jan 91	46.1	20 Feb 91	220.9
70.0	26 Jan 91	46.1	01 Feb 91	41.7
81.2	29 Jan 91	46.1	01 Feb 91	43.2
84.9	05 Feb 91	46.1	25 Feb 91	188.4
83.9	05 Feb 91	46.1	28 Feb 91	212.8
82.1	05 Feb 91	46.1	27 Feb 91	179.3
86.2	05 Feb 91	46.1	27 Feb 91	187.4
89.5	12 Feb 91	46.1	27 Feb 91	134.1
85.2	12 Feb 91	46.1	27 Feb 91	181.6
87.2	12 Feb 91	46.1	19 Feb 91	45.0
87.0	12 Feb 92	48.0	20 Feb 92	208.0

midline incision which was closed with Ethicon 00 sutures. Tracking was conducted both from boat and airplane using programmable scanning receivers (Advanced Telemetry Systems, Isanti, Minn.). Tracking efforts were initiated when transmitter-equipped fish were released. Searches were conducted daily to weekly until approximately mid-April. Weather dependent, bimonthly searches continued through the summer, and thereafter occurred irregularly.

Results

During 1984–1992, 626 adult shortnose sturgeon were captured by the 2 commercial shad fishermen (Table 1). Lengths ranged from 56 to 107 cm TL, and the modal size class was 71–75 cm TL (Fig. 1). Nineteen percent were female, 66% were male, and the remaining 15% were of undetermined sex. Numbers of fish captured per year ranged from 1 to 62 (mean ± sd = 27.2 ± 17.7) in the URA and 31–99 (51.5 ± 21.4) in the LRA. During 1985–1991, significantly ($P < .001$) more fish were captured in the LRA (377) than the URA (219). The ratio of males to females varied annually from 0.4:1 to 23:1 in the LRA and from 2.6:1 to 10:1 in the URA. Overall ratios were not significantly different: 3.2:1 in the LRA and 3.8:1 in the URA. The pooled sex ratio was 3.5 males:1 female. The percentages of females classified as ripe were 81% and 53% in the URA and LRA, respectively, and the percentages for ripe males were 50% and 42%, respectively. Accuracy of the percentages, especially for males, is somewhat in doubt due to the higher percentage (100%) classified as ripe through the biopsy method compared to the method used in previous years (Table 1). Ninety-five percent of the fish of unknown sex and maturity stage were captured in the LRA.

Juvenile Atlantic sturgeon co-occurred with adult shortnose sturgeon during January–April in the LRA, but not in the URA. In 1990, 3 Atlantic sturgeon were captured, while 6 were caught in both 1991 and 1992. Data on capture of juvenile Atlantic sturgeon were not recorded during previous years.

Eight fish were used successfully as broodstock and recaptured in following years. Of these, 1 female and 6 males were again used successfully. The female spawned after an interval of only 1 year (i.e., in 2 consecutive spawning seasons), and 2 males did likewise. Three males were ripe again after 2 years and 1 after 3 years, but whether they spawned in intervening years is not known. The eighth fish was a male which was unripe when recaptured after an interval of 1 year.

Twenty-four radio transmitters were implanted into adult shortnose sturgeon. With the exception of 1 individual captured and released in the URA in 1990, all fish used in radio telemetry efforts were captured and released in the LRA (Table 2). Ten of the 23 fish from the LRA ascended to the URA, and 1 ascended part way (to rkm 134) where contact was lost. Seven fish were relocated in or just below the LRA, while contact was lost immediately with 5 fish. Nine of the 15 fish (60%) implanted and released prior to mid-February ascended to the URA, compared to only 1 of the 8 (12.5%) released afterward. The maximum upriver locations (rkm) of these 10 fish were: 179, 182, 187, 188, 208, 213, 219, 221, 222, and 228. The 7 fish that were only detected in the LRA vicinity were recorded between rkm 36 and rkm 46 for 1 to 42 days. No fish were located later than mid-April in either the LRA or URA, and no fish were located in years other than that of release.

Discussion

Relative abundance of shortnose sturgeon was significantly greater in the LRA than in the URA. This may be due in part to the fact that fish migrating upriver to spawn are vulnerable to capture in the LRA during both the upriver and downriver segments of the migration. Nearly all fish that were considered not suitably ripe for use as broodstock were captured in the LRA, suggesting that each year some portion of the population neither spawns nor participates in the upriver migration. These fish possibly remain in the LRA, or just below in slightly brackish water, throughout the spawning season and are therefore vulnerable to capture over an extended period. It is also possible, however, that fishing effort of 1 or both of the commercial shad fishermen varied without our knowledge in some instances, thus confounding our interpretation of the relative abundance data.

Telemetry data also suggest that only a portion of the population participates in the upriver spawning migration. For example, 30% of telemetered fish remained in or just downriver from the LRA, while 22% were never relocated after the day of release. Although failure to locate these fish may be attributable to transmitter failure in some instances, it is likely that at least some individuals crossed to the saline side of the fresh/brackish water interface, thereby attenuating the radio signals. Thus, the hypothesis that the fresh/brackish water interface area and the downriver portion of the LRA serve as a staging area for the spawning migration and a holding area for fish that do not participate in the upriver migration is supported by telemetry, relative abundance, and maturity stage data collected in this study.

Migrating shortnose sturgeon began moving upriver in late January to mid-March, traveling at average speeds of up to 50 km per day. Hall et al. (1991) reported upriver migration in the Savannah River during February and March at speeds of 1–33 km per day. Assuming that maximum upriver locations of telemetered shortnose sturgeon indicate sites of spawning activity, spawning in the Savannah River took place between rkm 179 and 228 primarily during late February but as late as mid-April and at temperatures of 9.8–16.5°C. In the Saint John River, Canada, shortnose sturgeon spawn later (May–June), but at similar temperatures (Dadswell 1976). Hall et al. (1991) reported spawning behavior during March in the Savannah River, and identified 2 probable spawning areas: rkm 179–190 and rkm 275–278. Four of 10 fish that migrated upriver in the present study were recorded in the lower of these 2 areas. However, the other 6 fish moved to rkm 208–228. The stretch of river between rkm 208 and 228 is similar to the probable spawning areas above and below (Hall et al. 1991), as it contains sharp bends with strong currents, submerged timber, and a substrate of gravel, clay, and sand. Areas of strong currents and scoured, coarse substrate provide the conditions believed necessary for successful spawning, egg attachment, and hatching. Sites with similar conditions and substrate are utilized as spawning habitats by shortnose sturgeon in the Saint John River, Canada, and the Connecticut River (Dadswell 1979, Buckley and Kynard 1985).

Telemetry data suggest that most shortnose sturgeon left the freshwater portion of the Savannah River by mid-April. This was also reported by Hall et al. (1991), who noted that shortnose sturgeon in the Savannah River had left fresh water by early May, although some remained in the vicinity of the fresh/brackish water interface through the summer. In contrast, in the northern portion of this species' range, from the Hudson River to the Saint John River, shortnose sturgeon apparently utilize freshwater habitats more extensively, with segments of some populations remaining in fresh water throughout the year (Dadswell 1979, Buckley and Kynard 1985). Juvenile Atlantic sturgeon are occasionally captured at and just above the fresh/brackish water interface, but not upriver near spawning areas, during the shortnose sturgeon spawning season.

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Habitat Utilization and Biological Characteristics of Adult Atlantic Sturgeon in Two South Carolina Rivers

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Abstract.—Thirty-nine adult Atlantic sturgeon *Acipenser oxyrinchus oxyrinchus* (136–234 cm total length) were caught in gill nets fished at historical sturgeon-fishing locations in the Combahee and Edisto rivers (South Carolina) during spring and fall 1998. All fish were tagged (with passive integrated transponders and darts), and radio and acoustic transmitters were surgically implanted in 29 fish. When possible, gonad biopsies were taken for sex and maturity-stage determination. Locations of telemetered fish were determined several times per week from airplanes (radio) and boats (radio and acoustic). Nominal ages, based on microscopic examination of pectoral spine cross-sections, ranged from 7 to 20 years. Of the 28 fish for which sex was definitively ascertained, 21 (aged 7–15) were male and 7 (aged 15–20) were female. All fish moved out of the rivers during the period extending from October to November. Twelve fish returned the following spring (most in March), and many took up residence at the same sites utilized the previous year. Fall and spring spawnings were documented based on histological examination of gonad biopsies and directed upriver movements of fish during both seasons. Habitats used during summer were diverse and included the lower and upper estuaries, tidal freshwater, river, and perhaps even the ocean, as some fish left the system entirely. One male was captured in two successive springs and was in spawning condition (running ripe) both years.

The Atlantic sturgeon *Acipenser oxyrinchus oxyrinchus* is an anadromous species inhabiting the Atlantic coast of North America from Labrador to Florida. Recorded exploitation dates prior to 2198 BC (Ritchie 1969). By 1860, major commercial fisheries were established in a number of states from Georgia through New York (Smith 1990). Because of the high value of these fish, the fisheries were vigorously pursued, and within a decade, all fisheries suffered drastic declines or total collapse (Murawski and Pacheco 1977).

After the collapse of the more northerly fisheries, South Carolina became a major producer of sturgeon. In 1976, South Carolina produced 55% of the total U.S. landings of Atlantic sturgeon (Smith et al. 1984). As a result of increased fishing pressure following the embargo on Iranian caviar, landings continued to increase in South Carolina, but catch per unit effort was steadily declining. By 1984, it became apparent that the fishery was being overexploited, and in 1985 the South Carolina sturgeon fishery closed indefinitely until systems for estimating abundance and monitoring the fishery could be implemented. Recently the Atlantic States Marine Fisheries Commission (ASMFC 1998) implemented a long-term moratorium on all U.S. Atlantic sturgeon fisheries.

Little is known about the ecology of adult Atlantic sturgeon in the southeastern United States. The ASMFC conducted an information survey while developing a Fishery Management Plan and noted that research on habitat use and reproduction/recruitment should be considered a high priority (ASMFC 1990, 1998). To date, however, no spawning areas have been identified in any southeastern river, nor have specific spawning conditions been defined. Further, habitat use by adult Atlantic sturgeon during nonspawning seasons is unknown. Age-distribution and sex-ratio information are also unavailable for most southern populations. Thus, a broad range of biological data is needed to facilitate restoration and management of this valuable species (Smith 1985; Smith and Clugston 1997). To address these issues, a study was conducted to provide information on habitat use, age distribution, reproductive status, and seasonal movements of adult Atlantic sturgeon in two South Carolina rivers.

Methods

With assistance from three former sturgeon anglers who were familiar with the study areas, sturgeon gill nets were deployed in the Combahee and Edisto rivers of the Ashepoo, Combahee, and Edisto rivers (ACE) basin (South Carolina) during

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being typical of spawning sites for a number of sturgeon species (Foltz and Meyers 1985; Parsley et al. 1993; Kieffer and Kynard 1996; Sulak and Clugston 1999).

Other areas that the data suggest might have been spawning sites were RKM 105 and 190 in the Edisto River and RKM 55 in the Combahee River. To reach the two upriver sites in the Edisto River, fish had to cross several very shallow (~0.5 m) stretches of river as a result of the low-flow conditions that prevailed during fall 1998. In spring, movements upriver of RKM 56 on the Edisto River were not observed, and no movement above RKM 60 was detected in the Combahee River. Dovel and Berggren (1983) suggested that Atlantic sturgeon in the Hudson River spawn between RKM 55 and 136, although the salt wedge extends as far upriver as RKM 98. Based on histological examination of gonads, Van Eenennaam et al. (1996) concluded that spawning did not take place below RKM 196 in the Hudson River. They also pointed out that based on the sensitivity of sturgeon embryos and larvae to even low salinities, it is doubtful that successful spawning takes place below, or even immediately above, the salt wedge. The proposed spawning sites in the Edisto and Combahee rivers were all more than 12 km upriver of the maximum intrusion of the salt wedges, and they are substantially farther upriver when the salt wedges are displaced downriver during typical flow conditions. Shortnose sturgeon *Acipenser brevirostrum* in general (Kynard 1997), Gulf sturgeon in the Suwannee River (Sulak and Clugston 1999), and Atlantic sturgeon in the Hudson River migrate more than 200 km upriver to spawn. However, this may not always be the case for Atlantic sturgeon in southern rivers, as some spawning in South Carolina may take place relatively close to the coast (but probably well above the salt wedge). This hypothesis is further supported by the recent capture (April 1998) of two very early larval *Acipenser* sp., tentatively identified as Atlantic sturgeon, at RKM 42 in the Savannah River (T. Reinert, Georgia Cooperative Fish and Wildlife Research Unit, personal communication). Sulak and Clugston (1999) hypothesized that Gulf sturgeon spawning sites are determined primarily by a specific topographical, hydrological, and chemical milieu, and such conditions may occur lower in the Edisto, Combahee, and Savannah rivers than in other rivers in which Atlantic sturgeon have been studied.

Migration patterns and general behavior of adult Atlantic sturgeon in the ACE basin closely parallel those of Gulf sturgeon (Sulak and Clugston 1998, 1999), perhaps to a greater extent than those of Atlantic sturgeon in the northern portion of their range. In general, both overwinter in the ocean, migrate into the river in early spring and move upriver to spawn, inhabit the river throughout the summer, and migrate out of the river in the fall. Maximum observed ages for Gulf and southern Atlantic sturgeons are much younger than those reported for northern Atlantic sturgeon. There is also some evidence of fall spawning for Gulf sturgeon (Sulak and Clugston 1998; Ken Sulak, U.S. Geological Survey, Biological Resources Division, personal communication) as well as for ACE basin Atlantic sturgeon. In contrast to Gulf sturgeon, however, Atlantic sturgeon in the ACE basin utilized a broad range of estuarine and riverine habitats during the summer.

This study provides new information on the movements and habitats of adult Atlantic sturgeon in the southeastern United States as well as evidence to substantiate a fall spawning period. However, significant data gaps still remain. For example, a number of sites were identified as probable spawning areas, but collection of eggs for final verification was not achieved. Nominal age structure and catch data suggest that the population in the ACE basin is rebuilding following the closure of the fishery, but population size estimates were not possible. It is not known whether the surprisingly diverse habitats used form a pattern that occurs in other rivers in the region. Atlantic sturgeon spend a substantial portion of their lives in the ocean and have been captured in depths of up to 40 m off the coast of South Carolina (Collins and Smith 1997), but little is known of their movements or specific habitats. Future efforts should focus on addressing these issues as well as on determining the status of Atlantic sturgeon populations in other rivers.

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NEWS for July 11, 2005

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A summary of SCDNR News Releases

Full-length articles follow these summaries, also fishing trends and tidetable. For more information, call the Communications Office of the S.C. Department of Natural Resources at (803) 734-3950 in Columbia. Check DNR's Web site to download articles and digital news photos, or for immediate needs, contact Mike Creel at CreelM@dnr.sc.gov . News releases, fishing reports and weekly tidetable are available to Internet users at www.dnr.state.sc.us. Weekly news text files and captioned image files may also be downloaded from ftp://www.dnr.state.sc.us/pub/news/DNRnews2005/

THIRD PHASE OF BONNEAU FERRY PROJECT COMPLETE WITH LAND TRANSFER TO STATE -- The third and final phase of the Bonneau Ferry land protection project in Berkeley County is now complete following the transfer of 3,397 acres from The Conservation Fund to the State of South Carolina. "Thanks to this extraordinary conservation partnership, the Bonneau Ferry project is now complete, protecting 10,712 acres of the 30,000-acre Cooper River Historic District," said John Frampton, director of the S.C. Department of Natural Resources (DNR). "The Bonneau Ferry property is an ecological and cultural treasure." The Bonneau Ferry Tract, home of bald eagles and endangered red-cockaded woodpeckers, lies between Mepkin Abbey and Cordesville and includes thousands of acres of timberland. #05-130

DNR LAW ENFORCEMENT ADVISORY GROUP MEETS JULY 13 IN COLUMBIA -- The Law Enforcement Advisory Committee to the S.C. Natural Resources Board will meet 10 a.m. Wednesday, July 13 in Room 335 (board room) of the Rembert Dennis Building at 1000 Assembly St. in Columbia. The meeting is open to the public. Anyone needing information or directions to the meeting may call Jessica Clements at (803) 734-3607 at the S.C. Department of Natural Resources (DNR) law enforcement headquarters in Columbia. #05-131

S.C. NATURAL RESOURCES BOARD TO MEET JULY 15 IN CHARLESTON -- The S.C. Natural Resources Board, the policy making body of the S.C. Department of Natural Resources, will meet 9:30 a.m. Friday, July 15 in the Marine Resources Division Auditorium at 217 Fort Johnson Road on James Island in Charleston. Board meetings are open to the public, and anyone with business for the board or needing directions to the meeting should contact the S.C. Department of Natural Resources Columbia office at (803) 734-9102. #05-132

LANCASTER BOAT RAMP DEDICATED TO LONG-TIME HATCHERY MANAGER -- The S.C. Department of Natural Resources recently dedicated the new boat ramp at Lancaster Reservoir as the William L. Catoe Boat Ramp in honor of the long-time manager of the Heath Springs fish hatchery. The new boat ramp was dedicated June 10 to honor Will Catoe for his 40 years of dedicated service as the hatchery manager of the Springs Stevens Fish Hatchery in Heath Springs in Lancaster County. Catoe retired from this position in June 2004 as the longest-serving fish hatchery manager in the history of the S.C. Department of Natural Resources. #05-133

STRIPER MORATORIUM SET TO END OCT. 1 ON LOWER SAVANNAH RIVER -- A harvest moratorium on striped bass in the Lower Savannah River - in place since 1991 while two states worked to restore the waning species - will officially end Oct. 1, 2005. This will allow anglers once again to keep some of the fish they catch. The affected area will include the Savannah River from the Lake Thurmond dam downstream to the mouth. Beginning Oct. 1, fishermen on the Lower Savannah River in South Carolina and Georgia waters will be able to keep a few of the striped bass and hybrids they catch. Since 1991, South Carolina anglers were permitted only catch-and-release fishing in the Savannah River from Augusta Diversion dam downstream to the mouth of the river. It had been illegal to harvest or keep any fish caught from Fields Cut below Savannah up to the Augusta

Also p. 6

Diversion Dam above Augusta, Ga. The Georgia Department of Natural Resources also plans to allow striped bass fishing with the same limits as South Carolina beginning Oct. 1, 2005. For questions about the upcoming striped bass season on the Lower Savannah River, the public can call the S.C. Department of Natural Resources (DNR) at (803) 734-3932 in Columbia. #05-134

UPSTATE YOUTH DOVE HUNT APPLICATIONS DUE BY AUG. 15 -- Two youth dove hunts, sponsored by the S.C. Department of Natural Resources, U.S. Forest Service and the Upper Savannah River Chapter of Quail Unlimited, will be held in the Upstate on Saturday, Sept. 3, the first Saturday of dove season. Applications for the youth dove hunts are due by Monday, Aug. 15. Interested youths or adults should call or come by the Clemson DNR office, 153 Hopewell Road (off Old Cherry Road), to receive an application. To request an application by phone, call the Clemson DNR office at (864) 654-1671, extension 24. Application requests may also be e-mailed to: MortonR@dnr.sc.gov. #05-135

NESTING CHIMNEY SWIFTS SOURCE OF NOISE NOW HEARD IN FIREPLACES -- South Carolina residents who are hearing strange noises coming from their chimneys can be assured that the visitors are friendly and helpful chimney swifts, the only bird in North America which nests almost exclusively in chimneys. Most homeowners were unaware that birds were nesting inside their chimneys until the young swifts started their loud food-begging calls at two weeks of age. It takes about 30 days after hatching for the young to leave the nest. Swifts are highly beneficial birds, do not spread vermin, and only use the chimney during the warm months when the fireplace is dormant. Like other birds protected by the Migratory Bird Treaty Act of 1916, chimney swifts are protected from being pursued, captured or killed. For more information, check out the North American Chimney Swift Nest Site Research Project Web site: http://www.chimneyswifts.org/. #05-136

STATE WATERFOWL REPORT IS NOW AVAILABLE ON-LINE -- A statewide waterfowl report that provides information on waterfowl population surveys and summaries of waterfowl harvests during the past two seasons is now available on-line from the S.C. Department of Natural Resources. Staff of the S.C. Department of Natural Resources (DNR) recently completed a report entitled "South Carolina Waterfowl Project Report 2003-04 and 2004-05." A team of DNR Wildlife Section biologists-Bob Perry, Dean Harrigal and Walt Rhodes-prepared the publication. All waterfowl project activities occurring during the past two fiscal years are summarized in the document, and the report is a continuation of waterfowl project reports prepared by Wildlife Section staff since the early 1970s. To read the document online or download your copy of the report, visit the DNR Web site at http://www.dnr.state.sc.us/wild/waterfowl/; or to obtain a copy call (843) 546-9489 or e-mail Bob Perry at PerryB@dnr.sc.gov. #05-137

DNR TO PARTICIPATE IN QUAIL UNLIMITED LANDOWNER HABITAT SESSION IN ATLANTA -- Landowners wanting to learn how to manage their property for bobwhite quail are encouraged to attend Quail Unlimited's National Convention and Wildlife Expo in Atlanta on Friday and Saturday, July 29 and 30. A "Landowner Habitat Advice and Planning" session will run from 9 a.m. to 5 p.m. both days. Participation is free and will be held at the Sheraton Atlanta Hotel (telephone number 404-659-6500). Landowners will have an opportunity to meet privately with wildlife biologists to receive habitat management suggestions, learn what financial incentives may be available and begin moving forward with a plan to improve bobwhite quail and other wildlife abundance on their property. Landowners interested in taking advantage of this free habitat management advice are encouraged to call (812) 536-2272 or e-mail bobwhite@psci.net to set up a time for a Friday or Saturday meeting. #05-138

FRESHWATER FISHING TRENDS

SALTWATER FISHING TRENDS:

The Sport Fish Restoration Program funds operations of the state's Public Fishing Lakes. The federal program follows the "user-pay" concept by providing revenue from an excise tax on fishing equipment and motorboat fuel.

- Written by Greg Lucas -

NEWS RELEASE #05-134 July 11, 2005 DNR News (803) 734-3950

STRIPER MORATORIUM SET TO END OCT. 1 ON LOWER SAVANNAH RIVER

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Beginning Oct. 1, fishermen on the Lower Savannah River in South Carolina and Georgia waters will be able to keep a few of the striped bass and hybrids they catch. Since 1991, South Carolina anglers were permitted only catch-and-release fishing in the Savannah River from Augusta Diversion dam downstream to the mouth of the river. It had been illegal to harvest or keep any fish caught from Fields Cut below Savannah up to the Augusta Diversion Dam above Augusta, Ga. The Georgia Department of Natural Resources also plans to allow striped bass fishing with the same limits as South Carolina beginning Oct. 1, 2005.

For questions about the upcoming striped bass season on the Lower Savannah River, the public can call the S.C. Department of Natural Resources (DNR) at (803) 734-3932 in Columbia.

Under the new law effective Oct. 1, any lawfully possessed fish of each of these species-striped bass, striped bass hybrids, white bass, or any combination-must be a minimum of 27 inches in total length. It will be unlawful to possess more than two striped bass, striped bass hybrids, white bass, or any combination of these species in the Savannah River and its tributaries and distributaries and the lands immediately adjacent to them from the J. Strom Thurmond Lake dam downstream to the mouth of the Savannah River defined by a line from Jones Island, S.C. (also known as Oysterbed Island) point at N 32 02, W 80 53; across Cockspur Island, Georgia, point at N 32 01, W 80 52 to Lazaretto Creek, Ga., point at N 32 01, W 80 52

On Dec. 10, 2004, after hearing biologists recommendations, the S.C. Natural Resources Board voted to lift the 1991 moratorium on striped bass fishing in the Lower Savannah River nine months earlier (October 2005) than had been planned and to ask the State Legislature to enact a law to lift the moratorium. The S.C. General Assembly during its 2005 session approved a bill (R100, S535) to lift the moratorium and establish catch limits. This bill was ratified as law on May 24 stating that the striped bass moratorium would end effective Oct. 1, 2005, and new creel and size limits would begin on that date. The new law amends Section 50-13-237 of the South Carolina Code of Laws.

In 1988, the Georgia Department of Natural Resources Wildlife Resources Division enacted a harvest moratorium for striped bass, with South Carolina DNR doing the same in 1991, as a protective measure after the population experienced drastic declines in the 1980s.

South Carolina DNR Fisheries biologist Chris Thomason said the drastic decline that occurred during the 1980s was a result of poor reproduction of the native striped bass population. A tide gate constructed in 1977 by the U.S. Army Corps of Engineers in the Back River, at Savannah, along with a diversion canal (New Cut), as well as channel deepening resulted in increased salinity levels, flow velocities and siltation in spawning areas. Since 1991, restoration efforts have included removal of the tide gate, filling of the diversion canal, and aggressive restocking by Georgia DNR. These stocking efforts have been very successful in increasing the numbers of striped bass in the Savannah River, with the current population approaching historic levels. Anglers have enjoyed the resurgence in the striped bass population over the last several years, and a popular catch and release fishery has developed.

Although the population has increased, most of the striped bass in the river are hatchery-reared fish. Therefore, Georgia DNR plans to continue its supplemental stocking and partner with South Carolina DNR in restoration and management efforts involving striped bass in the Savannah River, including natural recruitment assessments, annual population surveys and habitat improvement.

"Lifting the striped bass moratorium on the Lower Savannah River on Oct. 1 will allow anglers a chance to harvest fish for consumption and possibly trophy fish," Thomason said. The creel and size limit will also allow nearly all female striped bass to spawn at least once in order to continue the long-term goal of restoring the fishery to a self-sustaining population. Another benefit would be South Carolina DNR joining with the Georgia DNR to promote consistency in management and enforcement.

Thomason said that anglers have played a key role in helping striped bass return to harvestable numbers in the Lower Savannah by obeying catch and release rules and by funding recovery efforts through fishing license fees and the Federal Aid in Sport Fish Restoration program, which places a surcharge on fishing equipment such as rods and reels and lures.

-Written by Mike Creel -

NEWS RELEASE #05-135 July 11, 2005 DNR News (803) 734-3950

UPSTATE YOUTH DOVE HUNT APPLICATIONS DUE BY AUG. 15

Two youth dove hunts, sponsored by the S.C. Department of Natural Resources, U.S. Forest Service and the Upper Savannah River Chapter of Quail Unlimited, will be held in the Upstate on Saturday, Sept. 3, the first Saturday of dove season.

Applications for the youth dove hunts are due by Monday, Aug. 15. Interested youths or adults should call or come by the Clemson DNR office, 153 Hopewell Road (off Old Cherry Road), to receive an application. To request an application by phone, call the Clemson DNR office at (864) 654-1671, extension 24. Application requests may also be e-mailed to: MortonR@dnr.sc.gov.

One active gun per youth (adult may not shoot when either youth is shooting) is allowed per stand. Fifty shells are allowed per hunter. One adult and up to two youths may apply together and will use the same stand. Applicants who have at least one youth member of their hunting party who has not participated on a DNR youth dove hunt before will be given priority. Youth must be ages 5-15 and be accompanied by an adult 21 or older.

Fifty-five slots will be available for these two hunts. If more than 55 applications are received, a random selection will be held. Previous participants in the youth dove hunts are encouraged to sign up for these hunts and encourage a friend to do the same. Duplicate applications will be disqualified.

One of the hunts will be conducted in Pickens County and one in Oconee County near the Stumphouse Ranger

DOE 1997

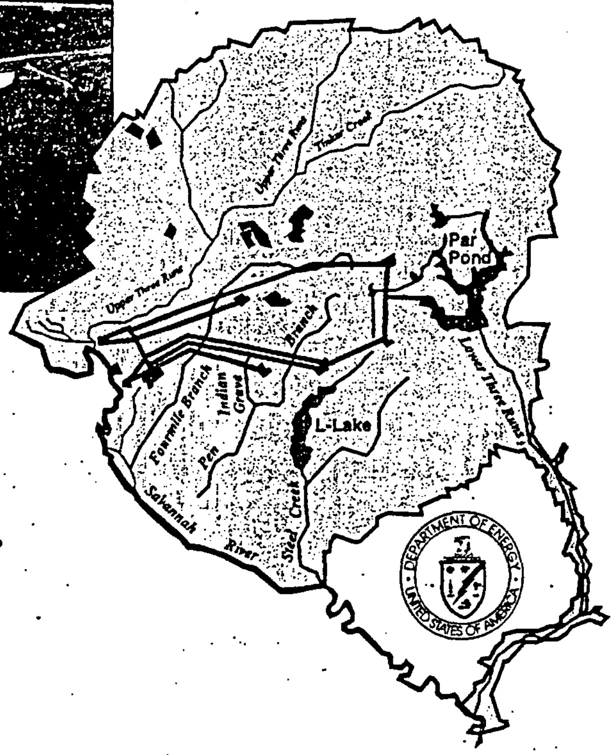
DOE/EIS-0268

V-527

Final Environmental Impact Statement

Shutdown of the River Water System at the Savannah River Site

May 1997



Department of Energy • Savannah River Operations Office • Aiken, South Carolina

COVER SHEET

RESPONSIBLE AGENCY: U.S. Department of Energy (DOE)

TITLE: Final Environmental Impact Statement, Shutdown of the River Water System at the Savannah River Site, Aiken, South Carolina (DOE/EIS-0268).

CONTACT: For additional information on this statement, write or call:

Andrew R. Grainger
Engineering and Analysis Division
SR NEPA Compliance Officer
U.S. Department of Energy
Savannah River Operations Office
P. O. Box 5031, Code DRW
Aiken, South Carolina 29804-5031
Attention: RWEIS
Telephone: (800) 242-8269
email: nepa@barms036.b-r.com

For general information on the DOE National Environmental Policy Act process, write or call:

Ms. Carol M. Borgstrom, Director
Office of NEPA Policy and Assistance (EH-42)
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
Telephone: (202) 586-4600, or leave a message at (800) 472-2756.

ABSTRACT: The purpose of the DOE action evaluated in this environmental impact statement (EIS) is to shut down the Savannah River Site River Water System in order to save money; that is, to prevent further expenditure of the funds necessary to operate a system that has no current mission. In the *DOE Savannah River Strategic Plan*, DOE committed to identifying and disposing of excess infrastructure. The River Water System has been identified as potential surplus infrastructure. As its Proposed Action and Preferred Alternative, DOE proposes to shut down and maintain the River Water System and to place all or portions of the system in a standby condition that would enable restart if conditions or mission changes required system operation. Consequently, DOE prepared this draft EIS to evaluate potential environmental impacts and to assess reasonable alternatives to this action. In this document, DOE assesses the cumulative environmental impacts of shutting down the River Water System, examines the impacts of alternatives, and identifies measures available to reduce adverse impacts. Evaluations of impacts on water quality, air quality, ecological systems, land use, geologic resources, cultural resources, and the health and safety of onsite workers and the public are included in the assessment.

In addition to the Preferred Alternative, described above, and the No-Action Alternative, which consists of continuing to operate the River Water System, this EIS examines an alternative to shut down and deactivate the River Water System.

PUBLIC COMMENTS: In preparing this Final EIS, DOE considered comments received by letter and voice mail, and statements given at two public scoping meetings in North Augusta, South Carolina on December 4, 1996. TC the number of alligators would increase until the carrying capacity (estimated to be around 500 individuals) was reached (Brandt 1991).

After Par Pond was drawn down (July-September 1991) Savannah River Ecology Laboratory scientists conducted studies to assess the effect of the drawdown on Par Pond alligators. Brisbin et al. (1992) reported that female alligators continued to guard nests even after the water had receded and all nests were more than 300 feet (100 meters) from the new shoreline. Brisbin et al. (1992) theorized that few hatchlings survived, noting that wading bird use of the area was heavy and that the young alligators were exposed to these and other predators (largemouth bass and other alligators) because of the lack of cover. There was also strong evidence for violent territorial encounters between adults that had left Par Pond and moved to other areas in search of better conditions (Brisbin et al. 1992).

Data from six alligator nests studied in the summer of 1994 during the Par Pond drawdown indicated that clutch sizes were reduced by 10.9 percent compared to pre-drawdown periods (Brisbin et al. in press). Body condition of hatchlings (based on length-weight relationships) was also lower. Nest predation appeared to have been reduced during drawdown, however, suggesting that negative reproductive impacts of the drawdown were to some extent compensated for by increased survival. When the reservoir was refilled in late-summer of 1994, flooding caused the destruction of one of six nests studied and caused an overall loss of 30.6 percent of eggs produced (Brisbin et al. in press). There was no evidence that females responded to rising water by making additions or alterations to their nests. Impacts to nests from rising water levels appeared to be a function of location and topography. L7-01

Savannah River Ecology Laboratory scientists recently completed a study that compared body burdens of mercury in alligators from Par Pond with alligators from the Florida Everglades (Yanochko et al. in press). Concentrations of mercury in kidney, muscle, and dermal scutes were lower in Par Pond alligators than Everglades alligators. There were no differences in mercury levels in tissues of animals collected before and after the Par Pond drawdown. The average concentration of mercury (4.1 milligram per kilogram) in muscle tissue of Par Pond alligators was higher than advisory levels established by the State of Florida (0.5 milligram per kilogram) or the U.S. Food and Drug Administration (1.0 milligram per kilogram) as safe for human consumption. L7-02 L7-C2

In January 1996, a large male alligator measuring more than 3.9 meters (13 feet) long was found dead in Par Pond (Brisbin 1997). Decomposition of the carcass made it impossible to determine the cause of death, but samples of muscle, kidney, and liver tissue were analyzed for mercury residues. Mercury content of these tissues, expressed on a wet weight basis, averaged 3.5 milligram per kilogram for muscle, 33.6 milligram per kilogram for kidney, and 158.9 milligram per kilogram for liver (Brisbin 1997). The reason for these unusually high levels of mercury is unknown, but long-lived species such as the alligator tend to accumulate more mercury than other groups, such as amphibians and fish, that have much shorter life spans. Mercury concentrations in tissues of individual animals within a population may vary dramatically with differences in age, body size, diet, metabolic rate, sex, state of sexual maturity, condition, habitat preference, and time of year. The alligator found in Par Pond was at least 22 years old, and may have been considerably older. TC

Shortnose sturgeon (*Acipenser brevirostrum*)

The shortnose sturgeon is an anadromous fish that spawns in large Atlantic coastal rivers from New Brunswick, Canada, to north Florida (Scott and Crossman 1973). A species of commercial importance around the turn of the century, the shortnose sturgeon is now listed by the National Marine Fisheries Service as an endangered species. The decline of the species has been attributed to the impoundment of rivers, water pollution, and overfishing; recruitment rates appear to be too low to replenish depleted populations (Heidt and Gilbert 1978).

Shortnose sturgeon grow slowly, reach sexual maturity relatively late in life, and live as long as 30 years (Scott and Crossman 1973). Fish from southern populations can grow faster and mature earlier than those from northern populations (Heidt and Gilbert 1978). Spawning occurs in, or adjacent to, deep areas of rivers with significant currents [1 to 4 feet (0.3 to 1.2 meters) per second] during spring when water temperatures warm to 48 to 59°F (9 to 15°C) (Crance 1986; Rulifson, Huish, and Thoeson 1982). Adults apparently return to natal streams to spawn at 2- to 5-year intervals (Rulifson, Huish, and Thoeson 1982). Eggs are heavier than water and adhesive after fertilization, sinking quickly and adhering to sticks, stones, gravel, and rubble on the stream bottom (Crance 1986). The interaction of water temperature, current velocity, and substrate type apparently determines suitability of spawning habitat as well as hatching success. Very few larvae and juveniles have been collected, so little is known of their distribution and movement (Rulifson, Huish, and Thoeson 1982).

Before 1982 shortnose sturgeon were not known to occur in the middle reaches of the Savannah River. However, 12 shortnose sturgeon larvae were collected near SRS in a 4-year (1982 through 1985) DOE study of ichthyoplankton abundance and entrainment in reactor cooling water systems (DOE 1987b). When shortnose sturgeon were first collected in 1982 and 1983, DOE notified the National Marine Fisheries Service as required under Section 7 of the Endangered Species Act of 1973 (Muska and Mathews 1983). A subsequent biological assessment evaluated the potential impact of SRS operations on shortnose sturgeon. The assessment concluded that "existing and proposed operations (specifically L-Reactor) of the Savannah River Plant will not affect the continued existence of the shortnose sturgeon in the Savannah River" (Muska and Mathews 1983). This conclusion was based on the facts that (1) shortnose sturgeon spawned upriver and downriver of the SRS; (2) passage up and downstream was not blocked by thermal effluents; (3) shortnose sturgeon did not spawn or forage in SRS streams and swamps that received thermal discharges; (4) entrainment was unlikely because shortnose sturgeon eggs are demersal, adhesive, and negatively buoyant; and (5) impingement of healthy juvenile and adult shortnose sturgeon on cooling water system screening devices is highly unlikely given their strong swimming ability. The National Marine Fisheries Service concurred with the DOE determination that SRS operations did not threaten the Savannah River population of shortnose sturgeon (Du Pont 1985).

A South Carolina Wildlife and Marine Resources Division (now South Carolina Department of National Resources) study of seasonal movement and spawning habitat preferences of Savannah River shortnose sturgeon found two probable spawning sites, one upstream of SRS at river mile 177-179 (river kilometer 285-288) and the other downstream of the Site at river mile 115-121 (river kilometer 185-195) (Hall, Smith, and Lamprecht 1991). The *Comprehensive Cooling Water Study* (Du Pont 1985) suggested that shortnose sturgeon spawned as far upstream as the first migratory obstruction, the New Savannah Bluff Lock and Dam. The South Caroline Wildlife and Marine Resources Division study appears to support this theory.

4.3.5.3.2 Environmental Impacts

Red-cockaded woodpecker

No Action

Although there are two inactive red-cockaded woodpecker colonies within a mile (1.6 kilometers) of L-Lake (Colony 61 to the west, in the vicinity of Substation Number 3 and Colony 62 to the east, near the intersection of Roads B-4 and B-5), there are no active colonies within several miles of the reservoir. Therefore, none of the activities associated with the No-Action Alternative at L-Lake would affect this wood-

V-528

(Dudley, et. al 1977)

Movements of Adult Striped Bass (*Morone saxatilis*) in the Savannah River, Georgia

RICHARD G. DUDLEY, ANTHONY W. MULLIS,[1] AND JAMES W. TERRELL[2]

School of Forest Resources
University of Georgia, Athens, Georgia 30602

ABSTRACT

During 1973, 1974, and 1975 movements of 33 striped bass [*Morone saxatilis* (Walbaum)] in the Savannah River, Georgia were followed through the use of ultrasonic and radio transmitters. During March through May striped bass congregate and spawn in a tidally influenced, relatively shallow, small branch of the river (Little Back River) near Savannah, Georgia, about 30 km upstream from the river mouth. During the spawning season striped bass do not exhibit any specific movement pattern, but remain in this particular sector of the river. Immediately after spawning, all tracked fish moved upstream, some as far as 301 km from the spawning area. Fish remained in the upstream areas at least 4 months. We detected no fish moving downstream during this period. Our data and those from previous work strongly suggest that individuals in this population of striped bass spend the majority, if not all, of their lives in the Savannah River.

The striped bass [*Morone saxatilis* (Walbaum), family Percichthyidae] is native to the Atlantic coast of North America from the St. Lawrence River in Canada to the St. Johns River, Florida and in the Gulf of Mexico from western Florida to Lake Pontchartrain, Louisiana. Introduced to the Pacific coast in 1879, it now ranges from San Diego, California to the Columbia River, and possibly as far north as Alaska (Nichols 1966; Raney 1952).

Noted for their value to both sport and commercial fisheries, Atlantic coast striped bass populations contribute more than 9 million fish to sport fishermen (U.S. Department of the Interior 1970) and about 4,000 metric tons to commercial fishermen (Koo 1970) each year. The striped bass' habit of feeding on schools of pelagic clupeids has made it a valuable predator and popular sport fish in freshwater lakes and reservoirs as well.

Within its range on the Atlantic and Gulf coasts biologists have differentiated several races of striped bass based on clinal and other differences in meristic, morphometric, and biochemical characteristics (Raney and Woolcott 1955; Barkaloo 1967, 1970; Lewis 1957; Lund 1957; Morgan et al. 1973).

[1] Present address: 104 Emily Street, Elizabeth City, North Carolina 27909.
[2] Present address: 237 Lyons Street, Fort Collins, Colorado 80521.

Most striped bass are anadromous, and ascend rivers to spawn in fresh or brackish water in March to June when water temperatures reach 15 C to 19 C (Raney 1952; Stevens 1964; Barkaloo 1967). After spawning, followed perhaps by a short stay in fresh waters, most adult striped bass return to marine waters. A portion of those populations from Chesapeake Bay northward participate in a general northerly migration during the early and midsummer following spawning. These fish then return to wintering areas prior to entering home streams to spawn.

Striped bass populations from southern North Carolina southward do not contribute to this northward migration (Raney 1954). A 3 year fishery survey of coastal Georgia found striped bass only in tidal creeks and rivers (Mahood et al. 1974). Smith (1970), after tagging striped bass in the Savannah River, received no tag returns from coastal waters. However, local fishermen catch adult striped bass more than 300 km upstream in the Savannah River from May to September and catch fish in the extreme downstream tidal reaches of the river during the winter. The major known spawning area for striped bass in the Savannah River is in the tidally influenced area 30 to 40 km upstream from the river mouth (Smith 1970; McBay 1968; Robert Rees, Richmond Hill Hatchery, Richmond Hill, Georgia, personal communication).

The growing sportfishery and increasing

industrial development on the Savannah River increase our need for a better understanding of this population, which may be typical of other southern striped bass populations. Although previous work has helped delineate the spawning area in the Savannah River, these studies have not determined the extent to which this population is riverine, nor have they allowed a detailed description of the movements of these fish while in the river.

STUDY AREA

The headwaters of the Savannah River arise in the southern Appalachian Mountains of North Carolina, South Carolina, and Georgia at an elevation of about 1,600 m. They flow southeastwardly and at the confluence of the Seneca and Tugaloo rivers form the Savannah River which then flows 505 km to the Atlantic Ocean and forms the border between South Carolina and Georgia. Several dams blocking fish passage have been built on the Savannah River, but all these are more than 333 km upstream from its mouth. The New Savannah Bluff Lock and Dam, 301 km upstream, probably creates a partial barrier to fish movement. Striped bass are found above it, however, and the dam's gate type construction allows fish to pass under it. Fish probably go through the lock as well. Striped bass in this area may also originate from those stocked in upstream reservoirs. A navigation channel is maintained by the U.S. Army Corps of Engineers from the coast to Augusta (322 km).

The tidally-influenced sector of the Savannah River is divided into three branches (Fig. 1). The Front Savannah River (the most southwestern branch) is the widest branch and is the main channel for navigation. It receives effluent from a number of industries. The Little Back River (the most northeastern branch of the river) is more narrow and shallower than the Front River, and it is bordered on both sides by marshy vegetation and cypress forest of the Savannah Wildlife Refuge. Smith (1970) and McBay (1968) found that the Little Back River upstream from the U.S. Route 17 bridge and downstream from the mouth of Union Creek, is the primary striped bass spawning area, although some spawning occurs in upstream areas (Smith 1970). The Middle River lies between the Front and Little Back rivers, and it is similar to the Little Back River in depth, width, and vegetation types. In general, salinity is less than one part per 1,000 upstream from U.S. Highway 17A and at or near zero upstream from U.S. Highway 17.

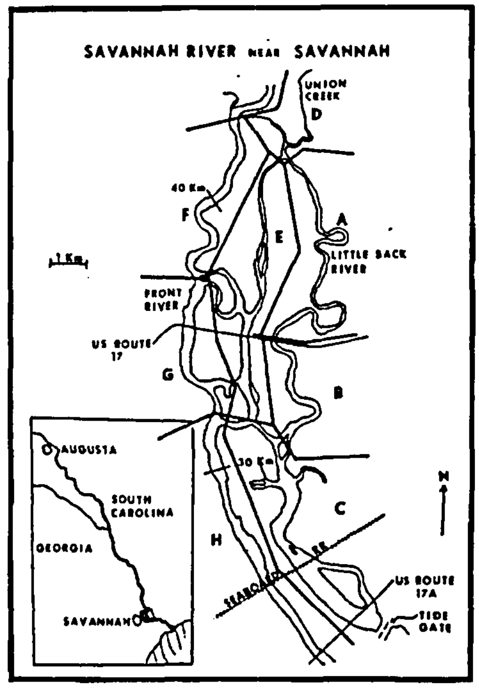


FIGURE 1.—*The Savannah River near Savannah showing the various branches of the river. Capital letters indicate the sections of the river used in the analysis of fish movements. The inset shows the relation of the enlarged portion, near Savannah, to the lower Savannah River.*

The river sector between the New Savannah Bluff Lock and Dam and the tidal area near the coast is fairly uniform and smooth flowing with a meandering pattern. In the Augusta area the Savannah River is characterized by a 25-km stretch of river above the New Savannah Bluff Lock and Dam that is similar to downstream segments. From about 5 km upstream from Augusta to 11 km upstream at the City of Augusta Dam, the river is rocky and shallow. Striped bass cannot go beyond the City of Augusta Dam.

Just upstream from Augusta four dis-

TABLE 1.—*Fish tagged and tracked during 1973 through 1975. Two other fish were tagged: one was never relocated; the other had a faulty transmitter. (Method—S = Surgical, O = Oral; Cause of termination—R = Regurgitated, L = Signal lost, P = Lack of personnel; Tag type—U = Ultrasonic, R = Radio.)*

Fish	Fork length cm	Weight kg	Sex	Start	End	Duration	Tag type	Tagging method	Cause of termination
				Spring 1973—Savannah					
SF	91.4	13.6	F	12 Apr.	20 Apr.	7.9	U	S	L
SX	83.8	10.2	M Ripe	19 Apr.	24 Apr.	4.7	U	S	L
SY	73.7	7.7	M Ripe	19 Apr.	8 May	18.9	U	S	P
SZ	52.1	2.1	M Ripe	19 Apr.	19 Apr.	0.1	U	S	L
				Spring 1974—Savannah					
SA	88.9	17.3	F	24 Mar.	1 Apr.	7.4	U	O	R
SB	71.1	6.4	F	27 Mar.	15 Apr.	18.9	U	O	R
SC	73.7	4.8	M Ripe	1 Apr.	20 Apr.	18.7	U	O	R
SD	83.8	10.2	M Ripe	4 Apr.	3 May	29.1	U	O	L
SE	83.8	8.6	M Ripe	4 Apr.	10 Apr.	5.8	U	O	R
SG	83.8	6.6	M Ripe	4 Apr.	21 Apr.	16.8	U	O	L
SH	88.9	11.4	M Ripe	4 Apr.	1 May	26.7	U	O	L
SI	99.1	13.6	F	10 Apr.	15 Apr.	4.9	U	O	R
SJ	81.3	9.1	M Ripe	17 Apr.	19 Apr.	1.9	U	O	L
SK	78.7	6.8	M Ripe	26 Apr.	7 May	10.8	U	S	L
SL	83.8	5.5	M Ripe	26 Apr.	22 May	26.1	U	S	L
SM	93.9	10.0	F Spent	28 Apr.	29 Apr.	1.1	U	O	L
SN	91.4	8.2	M Ripe	30 Apr.	2 May	1.9	U	S	L
				Fall and Winter 1974–1975—Augusta (upstream from lock and dam)					
RA	76.0	5.4		23 Oct.	22 Nov.	30	R	O	R
RB	86.5	7.5		7 Nov.	22 Feb.	107	R	O	R
RE	85.0	9.5		29 Jan.	28 May	120	R	S	L
				Fall and Winter 1974–1975—Augusta (downstream from lock and dam)					
RD	92.6	10.0		18 Dec.	29 Jan.	42	R	O	R
				Spring 1975—Savannah					
RG	84.0	10.0		4 Mar.	18 June	107	R	S	L
RI	93.7	14.1	M	12 Mar.	28 May	78	R	S	L
RJ	93.2	14.3	M	25 Mar.	31 July	129	R	S	L
RK	84.7	9.5	F	25 Mar.	28 Apr.	35	R	S	L
RL	97.5	13.6	F	1 Apr.	19 Apr.	19	R	S	L
RM	86.5	11.3	F	8 Apr.	13 June	67	R	S	L
RN	101.0	18.1	F	19 Apr.	11 June	54	R	S	L
RO	82.4	9.3	M	19 Apr.	31 July	104	R	S	L
RP	78.0	7.7	F	19 Apr.	25 Apr.	7	R	S	L
RQ	100.0	18.8	F	23 Apr.	25 Aug.	125	R	S	P
RS	76.0	7.2	M	28 Apr.	25 Aug.	120	R	S	P
RT	94.5	13.6	F	28 Apr.	29 May	32	R	S	L

charge canals enter the Savannah River from the Augusta Canal which originates at the City of Augusta Dam. These discharge canals harbored striped bass during much of the year.

Most sectors of the Savannah River suffer from some form of pollution (Georgia Water Quality Control Board 1972a, 1972b; U.S. Environmental Protection Agency 1972).

METHODS

We captured striped bass with electrofishing gear or with a pound net. After capture, we weighed and measured each fish and tagged it with an external dart tag. If the fish was large enough a radio or ultrasonic transmitter was inserted.

Initially, in 1973, we tagged fish surgically. We quieted the fish with quinaldine or by electronarcosis and made a slit about 3 cm long near the ventral midline, anterior of the anus. A transmitter was inserted and the opening closed with sutures. Since some fish died during surgery, we tagged 11 fish in early 1974 by placing transmitters into the fish's stomach via the mouth. With some fish we placed a transmitter in the stomach after attaching a short piece of monofilament line and a small trebel hook. We had hoped that the hook would prevent regurgitation of the tag, but regurgitation occurred anyway, perhaps because the hook was corroded by digestive juices. Due to this difficulty, we returned to the surgical implantation procedure for most of the remaining fish tagged during 1974 and all fish tagged during 1975.

We used both ultrasonic and radio tracking equipment to study movements of striped bass in the Savannah River. The ultrasonic transmitters, type SR69A from Smith-Root Electronics (Vancouver, Washington),[3] which emit an ultrasonic signal at 74 kHz, measured 14 mm and 19 mm in diameter at the two ends and 90 mm in length. They weighed about 40 g in air, 20 g in water, and had a volume of about 20 ml. The radio transmitters, obtained from AVM Instrument Co. (Champaign, Illinois), had an irregular shape and measured 60 by 21 by 10 mm. They weighed about 20 g in air and 10 g in water, had a volume of about 10 ml, and emitted a pulsed radio signal at 50 mHz. Receiving equipment used was manufactured by the maker of the respective transmitter type. Since a 15-kg fish tagged with an ultrasonic transmitter would have to increase its air bladder volume by only 1.8% to maintain neutral buoyancy, we assumed the transmitters did not drastically alter fish behavior (Marshall 1966).

Fish tagged during 1973 and 1974 (ultrasonic transmitters) were located as often as possible, and at times virtually continuously for 24 h to study movements of these fish in the spawning areas. Fish tagged in 1975 (radio transmitters) were monitored less often, especially when they migrated upstream from the spawning areas. Attempts were made to find these fish at least once a week after they left the spawning grounds but some fish were more readily found than others. Fish tagged in the fall of 1974 (radio transmitters) in the Augusta area were located every one to two weeks. Except for the four fish tagged in the Augusta area, all fish fitted with transmitters were captured in the spawning area.

Although our primary interest was to determine the movements of striped bass in the Savannah River, we had the opportunity, especially during 1974, to attempt to correlate short term movements of the fish with environmental variables. To do this we measured surface water temperature, salinity, and dissolved oxygen in the immediate vicinity each time a fish was located. We also recorded lunar stage, tidal stage, time and date. To facilitate analysis, we divided the tidal cycle into 12 stages and divided the lunar cycle into eight stages. The location of each fish was marked on a nautical chart of the area and numbered. This number and the corresponding data was then recorded on data sheets maintained for each fish.

Minimum rates of fish movement were estimated by dividing the distance between successive locations by elapsed time. The data used for this type of analysis did not include observations separated by more than 1.5 h. We used multiple regression analysis to find what variables would best predict movement.

RESULTS

From 1973 through 1975, 33 striped bass were successfully tagged and tracked (Table 1).

Movements of Striped Bass During the Spawning Season

Striped bass electronically tagged and tracked during March and April utilized the Little Back River and its tributaries more than any other part of the lower Savannah River. By examining data from fish tracked in this part of the river for more than 4 days, we found that striped bass spent about 75% of their time in the Little Back River (Table 2, Section A and B, Fig. 1). Forty-three percent of their time was spent in the Little Back River between the Route 17 bridge and the mouth of Union Creek (Section A on Fig. 1). The proportion of time fish spent in Section A differed significantly among the 3 yr ($\chi^2 = 87.16$, df = 2). Some of the differences in use of different sections of the river among years may be due to differences in data collection. Environmental factors may have contributed to the differences between 1974 and 1975. For example, in 1974 water temperature reached a high of 21 C in late March, dropped to 14 C, and then rose again. In 1975 water temperatures did not reach 21 C until early May. The temperature regime of 1974 may have caused the fish to meander more.

[3] Mention of products in this paper does not imply endorsement of those products.

TABLE 2.—*Utilization of various sections of the lower Savannah River by striped bass during the spawning season. Each number represents the number of days on which each fish was found in a particular section. If a fish was observed more than once per day in a given section this was counted as one observation. If this fish was found in more than one section on a given day this was counted as one observation in each section. Only fish observed on more than 4 days on the spawning grounds are presented here. See Fig. 1 for location of river sections.*

		River section								
Year	Fish	A	B	C	D	E	F	G	H	Total
1973	SF	5	2	1						
	SY	2	2							
	Total days	7	4	1						12
	% of total	58%	33%	8%						
1974	SB	5	3	8					1	
	SC	6	5	5	3	1				
	SD	2	1	1	6	3	1			
	SE	5			2					
	SG	8	4		5	1				
	SH	14	13							
	SI	3	3		2					
	Total days	43	29	14	18	5	1		1	111
	% of total	39%	26%	13%	16%	5%	1%		1%	
1975	RG	2	1		1					
	RI	6	17	2	2					
	RJ	6	3							
	RK	10		1	2					
	RL	5	7	1						
	RM	5	5		1					
	RO	6	1							
	Total days	40	34	4	6					84
	% of total	48%	40%	5%	7%					
1973–1975	Total days	90	67	19	24	5	1		1	207
	% of total	43%	32%	9%	12%	2%	0.5%		0.5%	

Striped bass tended to move more when the water was cooler (Fig. 2) but we obtained very little continuous data at water temperatures below 14 C. However, regression tests indicated that movement was significantly ($P < 0.1$) higher at lower temperatures.

Although movement patterns of individual striped bass differed greatly, as a group they tended to move primarily during the afternoon and early evening (Fig. 2) while in the spawning area. The few fish which were tracked continuously to about 32 km upstream in 1974 tended to move at night while in upstream areas, but there are too few data to draw any definite conclusions.

Fish tended to move less at flood tide than at any other tide and seemed to move more when the tide was dropping than when it was rising (Fig. 2). Due to the large confidence intervals no statistical significance can be attached to the data although cyclic (cubic and fourth power) regressions were tested.

Fish tended to move least during the period surrounding the new moon (Fig. 2). A cyclic relationship seems to be present in the data (Fig. 2) but again large variances prevent the assigning of statistically significant cyclic (cubic or fourth power) relationships.

Using multiple regression we found significant relationships between movement on the spawning grounds and the following combinations of variables: (1) water temperature and change in water temperature ($R^2 = 0.07$); (2) lunar stage and tidal stage ($R^2 = 0.05$); and (3) lunar stage, tidal stage, and season ($R^2 = 0.07$). Since none of these combinations accounted for more than 7% of the variability in the movement data and were significant only at the $P \leqslant 0.1$ level, the regressions have no predictive value.

Movement of Striped Bass after the Spawning Season

The movement patterns of striped bass changed markedly at the end of the spawn-

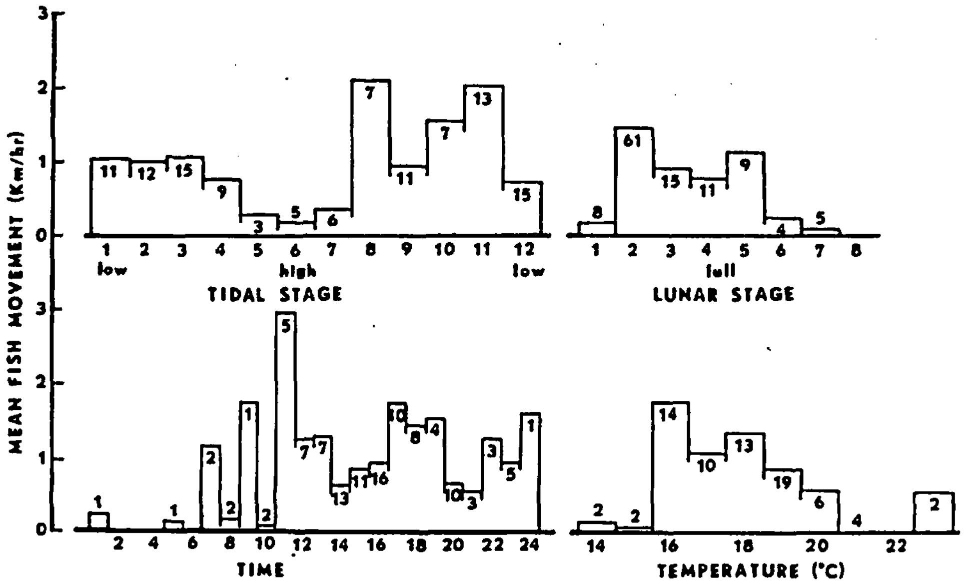


FIGURE 2.—*Relationship between some variables and movement of striped bass on the spawning grounds in the spring of 1974. In most cases small sample sizes within each category and large variances precluded the assignment of statistically significant relationships. Numbers of observations are given at the tops of columns.*

ing season. After remaining in a relatively confined area of the Little Back River all fish left this area. Of 20 fish which contained working tags when they left the spawning grounds, 14 were subsequently found upstream; six were never found. Only three of 12 radio-tagged fish were not found after spawning.

Most fish observed left the spawning area between 16 April and 1 May. Fish RG may have left the spawning area quite a bit earlier (18 March) than the other fish, but this fish was not relocated for almost 2 months. Excluding fish RG the mean date of last observation on the spawning grounds was April 25 (± about 5 days). Male fish did not leave on a significantly different date from females. Fish tagged in 1974 did not leave the spawning area earlier in spite of the warmer water temperatures which occurred that year. Fish which were not later located did not leave at a different date than those which were located.

Striped bass tagged with ultrasonic transmitters provided little information on post-spawning movement. Striped bass tagged with radio tags were easier to locate in upstream areas than ultrasonic tagged fish and were found for several months. Some striped bass moved upstream quite rapidly after spawning. Two radio-tagged fish (RI and RN) moved 240 km upstream from the spawning grounds in less than 3 weeks. Another (RJ) remained 136 km upstream for several weeks before moving further. Eight of the nine radio-tagged fish found after spawning moved at least 160 km upstream from the spawning grounds. The other fish (RT) was last located at the mouth of a tributary impassable to our boat. Most fish remained in a relatively short section of the river after the post-spawning migration (Table 3). We detected no significant downstream movement. The fish remained in upstream portions at least until we lost the transmitter signal.

Movement of Striped Bass in the Augusta Area

We tagged and tracked four striped bass captured near Augusta in the autumn and winter of 1974–75 (Table 1). None of these fish moved great distances and none exhibited movement patterns related to any obvi-

TABLE 3.—*Distances from the mouth of the Savannah River where individual striped bass remained for more than 5 days. Data are from fish tagged with radio transmitters in 1975. Of nine fish tagged and subsequently found upstream, these seven remained in specific areas more than 5 days. (Fish RI and RT moved steadily upstream until the signal was lost.) The last date shown is the last date on which a signal was found for that fish.*

Fish	Location (km from river mouth)	First found at this location	Last found at this location
RC	195	14 May	30 May
RJ	127–137	29 May	17 June
	257–280	15 July	31 July
RM	225–228	14 May	13 June
RN	283–291	10 May	11 June
RO	253–272	5 June	31 July
RQ	232–238	15 May	11 June
	249–252	19 June	25 Aug.
RS	293–301	19 June	25 Aug.

ous influence. Three fish (RA, RB, RE) tagged in or near the discharge canals were most often found either in the canals or within a few kilometers of them. They were never found more than 10 km from the tagging site. A fish (RD) tagged a few hundred meters downstream from the New Savannah Bluff Lock and Dam remained within 7 km of the dam.

Other Tagging Methods and Collections

Of 126 striped bass marked with external anchor tags only two were recaptured. One fish tagged at Augusta just downstream from the lock and dam in early November was found at the Savannah spawning grounds in March. One fish tagged (7 November 1974) in the Augusta area in canal 2 was captured by a fisherman about a month later in the rapids upstream from Augusta.

Striped bass were found (with electrofishing equipment) in the Augusta area both upstream and downstream from the lock and dam during the summer, fall and winter months. Fish were most likely to be found in the discharge canals, in the vicinity of a power plant downstream from Augusta and in a 1 km section of river downstream from the lock and dam. No fish were found in the spring when these sections were sampled on 16 April 1975. However, the water levels on this date were too high for efficient shocking.

DISCUSSION

In general the striped bass is an anadromous fish, but in the Savannah River the degree of anadromy is greatly reduced. This tendency in southern populations has been reported by previous workers (Barkaloo 1967; Raney 1952; Raney and Woolcott 1955).

Although our study strongly supports earlier studies (Smith 1970; McBay 1968) in establishing the Little Back River as the major spawning area, we did not discover what environmental characteristics attract striped bass to this area.

Our data indicate that most Savannah River striped bass migrate upstream after spawning and remain in the river. These fish must then return to the spawning grounds the following spring, although little direct evidence for downstream migration is provided by this study. This theory is supported by virtually all our data although some factors still remain unclear.

Although Mahood et al. (1974) found very few striped bass in a coastal survey of Georgia marine waters, fishermen do catch striped bass in the lower estuaries especially from 15 November through January 31. On the other hand we captured an adult striped bass (fish RD) just downstream from the lock and dam in December of 1974, and in January of 1974 we saw numerous striped bass in the rapids upstream from Augusta. The meaning of this latter observation is clouded by the existence of the lock and dam which may hinder free movement of fishes. Striped bass may remain in all parts of the river in winter, and then perhaps move toward the spawning area in February or early March. Striped bass were not captured in the Augusta area during the spawning season which might indicate that they did move downstream to spawn, but water conditions in Augusta hampered sampling during that period.

A possible reason as to why riverine populations of striped bass developed may be their temperature preferences. Excessively warm coastal waters may limit seaward migration of striped bass. Merriman (1941) felt that the maximum water temperatures at which striped bass would be found were 25 to 27 C. Maximum temperatures found in the downstream (warmest) part of the Savannah River were 26 C in July through September 1971 (Georgia Water Quality Control Board 1972b). Maximum temperatures of marine waters along the coast of Georgia in 1974 (Mahood et al. 1974) reached 27 to 30 C.

In years of warm ocean temperatures (up to 18.5 C) on the Pacific coast, seaward migrations of striped bass occurred, while during cooler years bass remained in inland reaches of the San Francisco Bay-Sacramento River system (Radovich 1963). Temperature preference could also be the constraint on the riverine population of striped bass in the St. Lawrence River (Magnin and Beaulieu 1967; Beaulieu 1962). In general the larger rivers of the South are probably cooler than adjacent coastal waters and upstream portions are cooler than downstream waters. The construction of large reservoirs (e.g., Clark Hill and Hartwell on the Savannah River) lower the water temperatures of rivers further. Thus striped bass would be more likely to find acceptable temperatures by moving upstream after spawning.

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COMPREHENSIVE COOLING WATER STUDY FINAL REPORT

VOLUME V AQUATIC ECOLOGY

V-539

SAVANNAH RIVER PLANT

W. L. SPECHT, EDITOR AND COMPILER

DUPONT

E. I. du Pont de Nemours & Co.
Savannah River Laboratory
Aiken, SC 29808

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC09-76SR00001

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Approved by:

J. C. Corey, Research Manager
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ABSTRACT

The Comprehensive Cooling Water Study (CCWS) was initiated in 1983 to evaluate the environmental effects of the intake and release of cooling water on the structure and function of aquatic ecosystems at the Savannah River Plant. The initial report (Gladden et al., 1985) described the results from the first year of the study. This document is the final report and concludes the program. The report comprises eight volumes. The first is a summary of environmental effects. The other seven volumes address water quality, radionuclide and heavy metal transport, wetlands, aquatic ecology, Federally endangered species, ecology of Par Pond, and waterfowl.

FOREWORD

This study was initiated in response to a commitment by the U.S. Department of Energy (DOE) Savannah River Plant Operations Office to the U.S. Senate Armed Services Committee and the State of South Carolina. The study was a joint effort undertaken by DOE, Du Pont, and the Savannah River Ecology Laboratory of the University of Georgia.

The broad scope of this project and size of the report necessitated that it be subdivided into smaller, coherent subject areas. The resulting document contains eight volumes:

Volume Number	DP Number	
I	1739-1	Summary of Environmental Effects
II	1739-2	Water Quality
III	1739-3	Radionuclide and Heavy Metal Transport
IV	1739-4	Wetlands
V	1739-5	Aquatic Ecology
VI	1739-6	Federally Endangered Species
VII	1739-7	Ecology of Par Pond
VIII	1739-8	Waterfowl

Only Volume I is being generally distributed. Readers desiring to obtain additional volumes may do so by writing to the National Technical Information Service.

V-530

Freeman and Freeman 2001

Criteria for Suitable Spawning Habitat for the Robust Redhorse *Moxostoma robustum*

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A Report to
U.S. Fish and Wildlife Service

January 2001

Introduction

The robust redhorse, *Moxostoma robustum*, is a large imperiled catostomid fish native to southeastern Atlantic slope drainages. The species' known native range extends from the Altamaha River drainage in Georgia northward to and including the Pee Dee River drainage in North Carolina and South Carolina. Three known extant populations are now restricted to a limited portion of the Oconee River between Milledgeville and Dublin, Georgia, the Ocmulgee River between Macon and Hawkinsville, Georgia and the Savannah River in the Fall Line Zone around and below Augusta, Georgia and North Augusta, South Carolina. A viable population may also persist in the Pee Dee drainage, where a single individual was captured in an intensive sampling effort in April 2000.

The robust redhorse is considered an imperiled species because of the large apparent reduction in species' range and abundance. Even if the robust redhorse persists in the Pee Dee as well as the Savannah and Altamaha drainages, abundances are dramatically reduced compared to E. D. Cope's (1870) accounts of fishery catches of the sucker. All remaining populations persist in rivers with flows influenced by hydropower dams. The robust redhorse is uncommon or rare in the Ocmulgee, Savannah and Pee Dee rivers. The apparently largest population, in the Oconee River, displays some evidence of recent juvenile recruitment to the population; for example, we have observed smaller males joining spawning activity during two of the past six years. However, because the population is skewed toward older age classes, concerns remain that spawning or juvenile habitat may be limiting. Effects of flow alteration by dams on population dynamics of the robust redhorse are not known. Potential loss of suitable habitat as a result of hydrologic alteration, especially for life history stages considered having the narrowest habitat requirements, is a primary management concern.

Evaluating potential effects of proposed flow regimes below dams on habitat availability for a target species requires an understanding of habitat requirements for that species. This manuscript presents criteria for suitable spawning habitat for the robust redhorse, based on observations of spawning by the Oconee River population and a single observation in the Savannah River. We intend these criteria to be used for quantifying amounts of potential spawning habitat for the robust redhorse at target locations in relation to flow regimes. However, because these criteria are largely based on observations at one known spawning site, they should be revised if and when additional data on spawning habitat become available. Criteria are presented as ranges of depths, velocities and substrate compositions considered suitable for spawning by robust redhorse.

Methods

Oconee River Study Site - We observed spawning by the robust redhorse at the Avant Mine site (Figure 1), located in western Washington County, approximately 24 air km SSE from the center of Milledgeville, Georgia (32° 56′23″N, 083° 04′01″W) near Oconee River Km 193 (RM 120). At this point the Oconee River drains 8025 km^2 (3100 square miles) of the piedmont physiographic region and is approximately 32 river km downstream of Georgia Power Company's Sinclair Hydroelectric project. Just upstream of this site, a large scroll meander was recently truncated, thus forming two large oxbow lakes on either side of the channel. As a result, the main current of the river is directed at a large cut bank just upstream of the spawning site. Subsequent bank erosion has exposed a lens of lag gravel in this bank. Much of the instream gravel utilized by robust redhorse during spawning appears to have been deposited as a direct result of this large-scale bank erosion.

Habitat Measurements -Spawning activities of robust redhorse were recorded at the Avant site in April and/or May, 1995 - 2000 (Table 1). In 1995, 1997, 1998 and 2000, we characterized depths and velocities by taking measurements with a wading rod and electronic current meter (Marsh-McBirney, Model 201D) at 7 to 15 locations within the spawning area. Velocities were measured with the probe positioned at 60% of water depth, measured from the water surface. Persistent high flows during the spawning seasons of 1996, and equipment failure in 1999, prevented us from making habitat measurements where fish were spawning.

To characterize substrate composition where the fish were spawning, we used a freeze-coring device developed by Dr. Ervan Garrison (UGA Dept. of Anthropology) for obtaining intact cores of substrata. The freeze-corer is a hollow stainless steel probe with a pointed tip. A small diameter copper line threaded into the larger probe extends to the bottom of the hollow tip. The small copper line transfers liquid nitrogen to the bottom of the probe. As the nitrogen evaporates, the material adjacent to the probe is frozen for intact removal. Cores, typically 15-25 cm in length, were removed from marked spawning locales. The cores were photographed and carefully removed from the probe using a hammer and chisel. The location and distribution of eggs, if present, were noted. All material from each core was returned to the laboratory where it was dried, sorted by size, and weighed. We collected freeze-core samples in 1997, 1998 and 2000.

Savannah River Observations - Robust redhorse were observed exhibiting courtship and territorial behavior at a location downstream from the New Savannah Bluff Lock and Dam (Figure 2), on 31 May 2000. We collected depth and velocity data at this site on 6 June 2000, and also photographed the substrate. We estimated dominant particle size in the spawning area from the photograph, which included a ruler for scale.

Data Analysis - We plotted depths and velocities from the Oconee spawning site to show ranges and value distributions (e.g., median, interquartile spread) for each year, to facilitate among-year comparisons. Measurements made in different years represent independent observations, however measurements made within a year do not because they were taken across the spawning area to describe local habitat. Thus, we essentially have a sample size of 4 estimates of the depths and velocities used by spawning robust redhorse. Therefore, we did not arrange the measurements in frequency distributions as would be appropriate for a larger sample size of independent habitat-use observations. We used the range of observations across the four years to estimate suitable depths and velocities for spawning robust redhorse. Data collected at the Savannah River site were inspected for concordance with suitable ranges as estimated from the Oconee data.

We computed size-fraction composition of freeze-core samples as percent of total sample weight. For estimating suitable spawning substrate, we only used data for cores taken directly from a known spawning location.

Results

Timing of spawning - We observed spawning activities by robust redhorse at the Oconee River Avant site during late April (in 1999) and into the third week of May, at temperatures ranging from 17 - 26.7 °C (Table 1). In addition to observations at the Avant site, eggs and three spawning depressions were observed on a gravel bar approximately 15 km downstream from Avant in the Oconee River on 19 May 1992, with water temperature approximately 25 °C (B. J. Freeman and N. M. Burkhead, field data). Although spawning activity was not observed at this site, nuptial robust redhorse were captured near the gravel bar on 20 May 1992. The single observation of fish exhibiting courtship behavior in the Savannah River site occurred later (31 May 2000) than the Oconee observations, at a water temperature of 21 °C. Lack of spawning activity at the Avant site on dates in April 1996 and 1999, and in late May (1997 and 2000), despite water temperatures of 19 - 25 °C suggest that spawning is triggered and terminated by factors in addition to water temperature. In any case, spawning appears most likely to occur from the latter part of April through May.

Spawning habitat - All observed spawning activities at the Oconee site occurred around a mid-channel gravel bar. Spawning activities included a suite of behaviors. In brief, males "porpoised", breaking the water surface over the spawning area and held positions over the gravel bar while periodically bumping or butting one another. Females generally remained in a deeper, lower-velocity area upstream from the riffle formed by the bar, occasionally swimming into the riffle and aligning with a male. A second male would join the pair, and spawning occurred in a trio with the males flanking the female. Females usually swam back to the pool upstream from the riffle following a spawning event.

Depths and velocities in the spawning area differed among years as a result of differences in flow levels (which differed by a factor of 2 during observations across years). However, depth and velocity ranges broadly overlapped among years (Figure 3). These data also encompassed depths (0.43-0.73 m) and estimated water velocities (0.3 - 0.5 m/s) at the spawning depressions found in the Oconee River in 1992, and depths and velocities at the Savannah River site from 2000 (Figure 3). In 1995, we measured 10 depths and velocities in the holding area used by females, immediately upstream from the spawning area; these ranged from 0.33-0.60 m deep and 0.05 -0.21 m/s, compared to 0.29 - 0.57 m and 0.35 - 0.61 m/s in the spawning area.

Substrate at all spawning sites was dominated by gravel (2-50 mm; Table 2). Freeze-core samples taken in known spawning locations at the Avant mine site in 3 years were dominated by gravel measuring at least 4.75 mm. The larger fraction of the 3 samples analyzed from 2000 was sieved into three larger fractions (2-12.5 mm, 12.5-25 mm, 25-50 mm) than in 1997 and 1998. The 2000 data showed that the spawning gravel was dominated by particles > 12.5 mm, with this fraction about evenly divided between medium (12.5-25 mm) and coarse (25-50 mm, Table 2). Fine sand (<0.25 mm) made up < 2 % (range 0.4 - 1.8%, n = 11 cores) of samples by weight. We visually estimated dominant substrate fractions at the 1992 Oconee site as 25-50 mm gravel, and at the 2000 Savannah River site as 15-30 mm gravel.

Criteria for suitable spawning habitat - Based on these observations, we propose the following criteria be used to evaluate habitat suitability for spawning *Moxostoma robustum*::

Suitable water depth: 0.29 - 1.1 m
Suitable average water column velocity: 0.26 - 0.67 m/s
Suitable substrate: dominated by medium - coarse gravel, 12-50 mm, with < 30 % sand (0.25-2 mm) and minimal fine particles (<0.25 mm)

Discussion

Spawning habitat conditions described for the robust redhorse agree well with spawning habitat reported for other species of *Moxostoma.* Jenkins and Burkhead (1994) review known spawning behavior and habitat use by five redhorse sucker species, including the river redhorse *M. carinatum*, the likely sister taxon to *M. robustum.* Although spawning habitat has not been well quantified for most redhorse species, qualitative descriptions generally report the suckers spawning over gravel or small rubble in riffles, runs or pool tails. Jenkins and Burkhead cite one report of silver redhorse *M. anisurum* spawning in a water depth of 1.5 m and note that, if valid, "this would be deeper than that known for most redhorses". The river redhorse is known to spawn in "shallow area at the head of gravel-bottom riffles", with depths ranging from 0.2-1.2 m and velocities (measured near the substrate) of 0.6-1.0 m/s (work by Hackney, reviewed by Jenkins and Burkhead 1994). This description closely corresponds to our observations for the robust redhorse. Recent studies of black redhorse *M. duquesnei* and golden redhorse *M. erythrurum* (Kwak and Skelly 1992) and of greater redhorse *M. valenciennesi* (Cooke and Bunt 1999) similarly report these species spawning in depths of < 1 m with moderate to swift velocities (averaging 0.28 to 0.55 m/s across species) in riffles or shoals. Dominant substrate used in these studies ranges from fine gravel (2-8 mm) for golden redhorse, to "pebble" (16-64mm) for greater redhorse, to small cobble (64-130 mm) for black redhorse.

Despite general consistency in spawning habitat descriptions across redhorse species, the functional significance of habitat requirements is incompletely known. We hypothesize that substrate characteristics are most critical; substrate particles must be small enough to moved and allow egg deposition by spawning fish and yet large enough to provide interstitial spaces for eggs and developing larvae (Table 3). We suspect that sufficient intragravel flow to maintain dissolved oxygen levels and remove metabolic wastes also forms a critical component of suitable spawning habitat. As described by Kondolf (2000), intragravel flow depends on substrate permeability and hydraulic gradient. Permeability will be reduced by fine sediment in the gravel. A laboratory study has demonstrated reduced survival of robust redhorse larvae in gravel with $\geq$ 25% by weight sand (Dilts 1999). The amount of fine sediment is likely reduced when substrate is disturbed during spawning (Kondolf 2000; our observations); however, gravels with large amounts of sediments < 1mm are unlikely to provide suitable spawning habitat. Hydraulic gradient, the second component in intragravel flow, is created by a drop in water surface elevation over a gravel bed, as occurs at the interface of a pool and downstream riffle (Kondolf 2000). We hypothesize that this mechanism makes shallower areas more suitable for spawning the deep water, where hydraulic gradient and intragravel flow would be reduced (Table 3).

The spawning habitat criteria we present differ from an earlier set of robust redhorse spawning habitat criteria produced for use in an instream flow study in the Oconee River (EA 1994). The earlier criteria show optimal depth as about 0.76 to 1.8 m (2.5 - 6 ft), with suitability decreasing to 0 at 3.6 m depth (12 ft). Optimal velocities from the earlier criteria, 0.23 to 0.53 m/s (0.75 to 1.75 ft/s), agree more closely with our data. However the earlier criteria give "simple woody cover" as optimal, and give suitability values of 0.2 and 0.5 to coarse sand and cobble/irregular bedrock, respectively. (Optimal sutiablity is assigned to small and large gravel). None of our observations support the use of substrates dominated by sand, cobble or bedrock, nor do considerations of substrate requirements (Table 3). With respect to cover use, spawning fish at the Avant site do sometimes occur around mid-channel snags. However, we hypothesize that this association is incidental to the fact that the snags are part of, and may help detain, gravel deposits. We have many observations of spawns in gravel areas with no cover nearby.. The earlier criteria are primarily based on conditions where nuptial fish have been captured in the Oconee River, likely explaining the greater depths and wider range of substrates reported as optimal. It is possible that captured fish had in fact been spawning in those locations; it is also possible that fish had been captured in staging areas or in route to spawning sites.

The criteria we present entail three sources of uncertainty.

- The criteria are based on data collected at one site in the Oconee River over four different years. The habitat conditions used by spawning robust redhorse have been remarkably consistent among years despite variation in flows and changes in channel morphology as a result of erosion and deposition processes. Habitat data collected at a single spawning site in the Savannah River are congruent with the Oconee data. However, clearly, data are needed from additional locations to test the generality of the criteria based on observations at the Avant site.
- The criteria are necessarily based on observations made at lower relative flows. It is possible that the redhorse also spawns during higher flows, and thus deeper water, when direct observations are impossible. The only evidence we have that this is not the case is our observation that spawning activity, first porpoising and male interactions, followed by spawning, gradually increases as water levels fall. We

hypothesize that if fish spawn during high and low flows, we would see fish fully engaged in spawning activity as soon as the water level was low enough to permit observations.

- Spawning success in relation to variation in substrate characteristics, depth or water velocity is not known. Thus, although fish may be observed spawning over a range of conditions, the entire range may not provide equal levels of egg and larval survival.

Clearly, additional study of robust redhorse spawning habitat, including relations between habitat characteristics and reproductive success (e.g., Dilts 1999 study), is warranted. In particular, we believe study of intragravel flow in spawning locations is needed to improve our understanding of habitat-related mechanisms promoting reproductive success. We propose that until and if we can observe spawning at greater depths (e.g., with remote videography), the criteria based on spawning conditions at the Oconee site are the most appropriate descriptors of suitable spawning habitat.

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Table 1. Dates and water temperatures when *Moxostoma robustum* were observed spawning at the Avant Mine site, Oconee River, Washington County, Georgia.

Year	Dates Spawning Observed	Mid-day Water Temperature	Dates No Spawning Observed (Water Temperature)
1995 [1]	14 - 16 May	25 - 26.7 °C	No Data
	22 May	24 °C	
1996	20 May	25 °C	28 April (20 °C)
1997	10 - 13 May	20 °C	20-21 May (23-24 °C)
1998	17 - 19 May	24.5 °C	
1999	27 April	22.2 °C	10 April (20 °C)
	29 April	18.8 °C	15 April (18.8 °C)
	1 May	17 °C	29 May (25 °C)
	3 May	21.6 °C	
	18 May		
2000	23, 25, 26, 29 April	18 - 19 °C	
	1, 4 May	21 °C	

[1] Anglers reported see spawning activity for previous 2 weeks; kaolin-mine workers reported seeing suckers spawn at an upstream gravel bar as late as June during 1994, and that the gravel bar had shifted downstream to the "Avant site" in 1995.

Table 2. Substrate composition in *Moxostoma robustum* spawning locations, as measured by size fraction composition of sediment freeze-core samples. The fraction > 2 mm was sieved differently in 2000 than in 1997 and 1998. Values are percents of total sample weight.

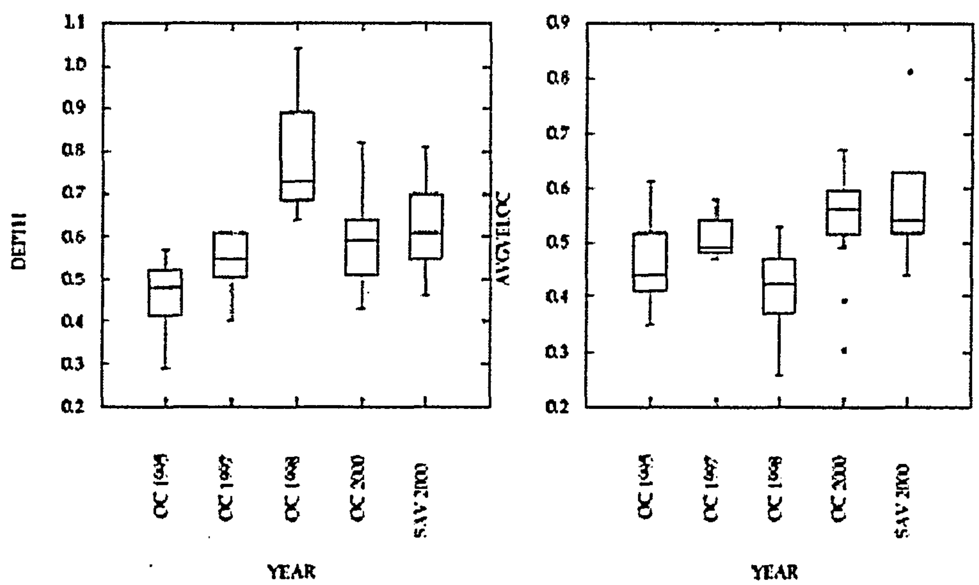
Year	Number of cores	Fines <0.25 mm	Sand 0.25-2 mm	Fine Gravel 2-4.75 mm	Fine Gravel 2-12.5 mm	Medium - Coarse Gravel >4.75 mm	Medium - Coarse Gravel 12.5 - 50 mm
1997	3	0.6	22.8	10.0	-	70.5	-
1998	5	1.2	26.9	5.1	-	65.9	-
2000	3	0.7	16.1	-	14.3	-	68.9[1]

[1] This fraction comprised 32% in 12.5-25 mm and 37% in 25-50 mm size classes.

Table 3. Habitat requirements to support spawning by redhorse suckers and empirical data for spawning robust redhorse.

Habitat Feature	Requirements	Field Data
Substrate	• moveable by spawning fish to allow egg deposition • resist scour and provide spaces for eggs and larvae and sufficient interstitial flow to maintain DO, remove wastes	Gravel substrate, most particles 12 - 50 mm; < 2 mm fraction < 30% of substrate by weight; < 0.25 mm fraction < 2%
Water Depth	• sufficient to accommodate courtship and spawning [sets minimum] • sufficient to maintain flow over eggs and larvae [sets minimum; possibly maximum if increasing depth reduces hydraulic gradient]	Range of observed spawning depths = 0.29 to 1.04 m
Water Velocity	• sufficient to maintain flow over eggs and larvae [sets minimum] • low enough to limit substrate scour	Range of observed average water column velocities in spawning areas = 0.26 to 0.67 m/s
Habitat juxtaposition	• provide holding areas for females adjacent to suitable spawning area • hypothesized: create hydraulic gradient to promote interstitial flow in spawning area	At Oconee River Avant site, spawning occurs in shallow area immediately downstream from a lower-velocity, pool where females hold while not spawning

Figure 3. Box and Whisker plots for depth (m) and average current velocities (m/sec) recorded in Robust Redhorse spawning areas in the Oconee and Savannah Rivers. Central horizontal bar represents the median value recorded; the upper and lower horizontal bars represent the 75th and 25th percentiles. Whiskers span plus and minus 1.5 times the interquartile width; asterisks represent values within 3 times the interquartile width.



(GDNR 2004) Section 2.4.1

Georgia Rare Species and Natural Community Information

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Pages

Rare Species Locations

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Please keep in mind the limitations of our database. The data collected by the Georgia Natural Heritage Program comes from a variety of sources, including museum and herbarium records, literature, and reports from individuals and organizations, as well as field surveys by our staff biologists. In most cases the information is not the result of a recent on-site survey by our staff. Many areas of Georgia have never been surveyed thoroughly.

The Georgia Natural Heritage Program can only occasionally provide definitive information on the presence or absence of rare species in a given area. Our files are updated constantly as new information is received. Thus, information provided by our program represents the existing data in our files on the date indicated on these pages and should not be considered a final statement on the species or area under consideration.

Available Data

Known rare species and natural community locations are available to the county and quarter quad level as both a web pages and a GIS coverage ESRI Shape file.

Locations by County

Select a county on this Georgia map or from the drop down box below to see a list of known rare species and natural community locations for that county.

County:

V-343

**These lists are for rare species and natural communities that are KNOWN to occur and which we have records of locations in our databases. Upon request to our office, we also have available POTENTIAL lists of species, which are likely to occur in the county if thorough surveys are performed (not available for every county). These lists are derived from the potential range of the species and should not be confused with the lists of known species provided here.*

Locations by Quarter Quad

Quarter quad data information is at the precision of one quarter (1/4) of a USGS 7.5 minute quadrangle map. Quarter quads are named using the USGS map name with a suffix (NW, SW, NE, SE). To locate a quarter quad, please go to the Orthophoto Viewer on the Georgia GIS Data Clearinghouse.

Select the letter below that corresponds to the first letter of the quarter quad that you want to see.

Quarter Quad Name:

Download ESRI Shape File

An ESRI Shape File of quarter quad and county rare species data can be downloaded here. This Shape File allows you to use your own GIS application to query information by species, quarter quad, county, and many other ways.

Most ESRI Shape Files include at lease three files. One of these files is a "dbf" (dBase IV) file. This dBase file can easily be opened in non-GIS databases and spreadsheets for querying and reporting.

The Shape File has a projection of ESRI Geographic (Lat/Lon), NAD27.

Contact Information

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next page

Locations of Special Concern Animals, Plants and Natural Communities in Burke County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of Information - 10/22/2004

Animals

GA · *Clemmys guttata* Spotted Turtle
· *Cyprinella callisema* Ocmulgee Shiner
· *Cyprinella leedsi* Bannerfin Shiner
· *Cyprinella nivea* Whitefin Shiner
· *Etheostoma fricksium* Savannah Darter
GA · *Fusconaia masoni* Atlantic Pigtoe Mussel
· *Hemidactylium scutatum* Four-toed Salamander
· *Heterodon simus* Southern Hognose Snake
· *Nerodia floridana* Florida Green Water Snake
· *Pituophis melanoleucus mugitus* Florida Pine Snake
· *Rana capito* Gopher Frog

Plants

GA · *Ceratiola ericoides* Rosemary
· *Dryopteris celsa* Log Fern
GA · *Elliottia racemosa* Georgia Plume
· *Lindera subcoriacea* Bog Spicebush
GA · *Nestronia umbellula* Indian Olive
US · *Oxypolis canbyi* Canby's Dropwort
· *Quercus austrina* Bluff White Oak
GA · *Sarracenia minor* Hooded Pitcherplant
US · *Sarracenia rubra* Sweet Pitcherplant
GA · *Scutellaria ocmulgee* Ocmulgee Skullcap
· *Silene caroliniana* Carolina Pink
GA · *Stewartia malacodendron* Silky Camellia

Natural Communities

· *CP MESIC BROADLEAF DECID.-BROADLEAF EVER. FOREST* Coastal Plain Mesic Ravine Forest

NOTE: This is a working list and is constantly revised (see element occurance data disclaimer). For the latest changes, acknowledgment of numerous sources, interpretation of data, or other information connected with this list, please contact:

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Locations of Special Concern Animals, Plants and Natural Communities in Jefferson County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of information - 10/22/2004

Animals

- *Acantharchus pomotis* Mud Sunfish
- GA · *Clemmys guttata* Spotted Turtle
- *Cyprinella leedsi* Bannerfin Shiner
- GA · *Fusconaia masoni* Atlantic Pigtoe Mussel
- US · *Haliaeetus leucocephalus* Bald Eagle
- *Heterodon simus* Southern Hognose Snake
- *Necturus punctatus* Dwarf Waterdog
- *Notropis chalybaeus* Ironcolor Shiner

Plants

- GA · *Nestronia umbellula* Indian Olive
- GA · *Penstemon dissectus* Grit Beardtongue
- US · *Sarracenia rubra* Sweet Pitcherplant

Natural Communities

No natural communities listed in Jefferson county.

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Locations of Special Concern Animals, Plants and Natural Communities in McDuffie County, Georgia

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"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of Information - 10/22/2004

Animals

- *Cyprinella nivea* Whitefin Shiner
- US · *Haliaeetus leucocephalus* Bald Eagle
- *Heterodon simus* Southern Hognose Snake
- GA · *Notropis scepticus* Sandbar Shiner

Plants

- *Arabis missouriensis* Missouri Rockcress
- US · *Aster georgianus* Georgia Aster
- *Elatine triandra* Longstem Waterwort
- *Macbridea caroliniana* Carolina Bogmint
- *Pilularia americana* American Pillwort
- *Saxifraga texana* Texas Saxifrage

Natural Communities

No natural communities listed in McDuffie county.

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Locations of Special Concern Animals, Plants and Natural Communities in Warren County, Georgia

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"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of information - 10/22/2004

Animals

GA · *Clemmys guttata* Spotted Turtle
· *Cyprinella callisema* Ocmulgee Shiner
GA · *Fusconaia masoni* Atlantic Pigtoe Mussel

Plants

GA · *Sedum pusillum* Granite Stonecrop
· *Silene caroliniana* Carolina Pink

Natural Communities

No natural communities listed in Warren county.

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Locations of Special Concern Animals, Plants and Natural Communities in Richmond County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concem lists for animals and plants. Date of information - 10/22/200‹

Animals

- *Cyprinella leedsi* Bannerfin Shiner
- *Cyprinella nivea* Whitefin Shiner
- *Elassoma okatie* Bluebarred Pygmy Sunfish
- GA · *Fusconaia masoni* Atlantic Pigtoe Mussel
- *Heterodon simus* Southern Hognose Snake
- *Necturus punctatus* Dwarf Waterdog
- *Rana capito* Gopher Frog

Plants

- US · *Aster georgianus* Georgia Aster
- *Astragalus michauxii* Sandhill Milkvetch
- GA · *Chamaecyparis thyoides* Atlantic White-cedar
- GA · *Cypripedium acaule* Pink Ladyslipper
- GA · *Hymenocallis coronaria* Shoals Spiderlily
- *Lindera subcoriacea* Bog Spicebush
- GA · *Nestronia umbellula* Indian Olive
- US · *Sarracenia rubra* Sweet Pitcherplant
- GA · *Scutellaria ocmulgee* Ocmulgee Skullcap
- GA · *Stewartia malacodendron* Silky Camellia
- GA · *Stylisma pickeringii var. pickeringii* Pickering's Morning-glory

latural Communities

Io natural communities listed in Richmond county.

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Locations of Special Concern Animals, Plants and Natural Communities in Monroe County, Georgia

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"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of information - 10/22/2004

Animals

- *Cyprinella callisema* Ocmulgee Shiner
- GA · *Cyprinella xaenura* Altamaha Shiner
- US · *Haliaeetus leucocephalus* Bald Eagle
- *Hybognathus regius* Eastern Silvery Minnow

Plants

- *Quercus prinoides* Dwarf Chinkapin Oak

Natural Communities

No natural communities listed in Monroe county.

NOTE: This is a working list and is constantly revised (see element occurance data disclaimer). For the latest changes, acknowledgment of numerous sources, interpretation of data, or other information connected with this list, please contact:

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Locations of Special Concern Animals, Plants and Natural Communities in Jones County, Georgia

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Animals

- *Cyprinella callisema* Ocmulgee Shiner
- GA · *Cyprinella xaenura* Altamaha Shiner
- GA · *Etheostoma parvipinne* Goldstripe Darter
- *Hemidactylium scutatum* Four-toed Salamander
- US · *Picoides borealis* Red-cockaded Woodpecker

Plants

- *Lindera subcoriacea* Bog Spicebush
- GA · *Nestronia umbellula* Indian Olive
- US · *Trillium reliquum* Relict Trillium

Natural Communities

No natural communities listed in Jones county.

NOTE: This is a working list and is constantly revised (see element occurance data disclaimer). For the latest changes, acknowledgment of numerous sources, interpretation of data, or other information connected with this list, please contact:

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Wildlife Resources Division
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Locations of Special Concern Animals, Plants and Natural Communities in Baldwin County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of Information - 10/22/200

Animals

US · *Haliaeetus leucocephalus* Bald Eagle
GA · *Moxostoma robustum* Robust Redhorse
· *Scartomyzon sp. 1* Brassy Jumprock

Plants

No plants listed in Baldwin county.

Natural Communities

No natural communities listed in Baldwin county.

NOTE: This is a working list and is constantly revised (see element occurance data disclaimer). For the latest changes, acknowledgment of numerous sources, interpretation of data, or other information connected with this list, please contact:

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Locations of Special Concern Animals, Plants and Natural Communities in Putnam County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concem lists for animals and plants. Date of information - 10/22/200

Animals

- *Cyprinella callisema* Ocmulgee Shiner
- GA · *Cyprinella xaenura* Altamaha Shiner
- *Hemidactylium scutatum* Four-toed Salamander
- GA · *Moxostoma robustum* Robust Redhorse
- US · *Picoides borealis* Red-cockaded Woodpecker

Plants

- US · *Amphianthus pusillus* Pool Sprite
- US · *Isoetes tegetiformans* Mat-forming Quillwort
- *Scutellaria nervosa* Bottomland Skullcap

Natural Communities

No natural communities listed in Putnam county.

NOTE: This is a working list and is constantly revised (see element occurance data disclaimer). For the latest changes, acknowledgment of numerous sources, interpretation of data, or other information connected with this list, please contact:

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Locations of Special Concern Animals, Plants and Natural Communities in Hancock County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of information - 10/22/200-

Animals

- *Cyprinella callisema* Ocmulgee Shiner
- US · *Haliaeetus leucocephalus* Bald Eagle
- *Hemidactylium scutatum* Four-toed Salamander
- GA · *Moxostoma robustum* Robust Redhorse
- *Pteronotropis hypselopterus* Sailfin Shiner
- *Scartomyzon sp. 1* Brassy Jumprock

Plants

- US · *Amphianthus pusillus* Pool Sprite
- *Aster avitus* Alexander Rock Aster
- *Elatine triandra* Longstem Waterwort
- *Eriocaulon koernickianum* Dwarf Pipewort
- *Fimbristylis brevivaginata* Flatrock Fimbry
- US · *Isoetes tegetiformans* Mat-forming Quillwort
- *Lindera subcoriacea* Bog Spicebush
- *Pilularia americana* American Pillwort
- GA · *Stewartia malacodendron* Silky Camellia

Natural Communities

No natural communities listed in Hancock county.

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Locations of Special Concern Animals, Plants and Natural Communities in Washington County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of information - 10/22/2004

Animals

- *Acantharchus pomotis* Mud Sunfish
- *Cambarus truncatus* Oconee Burrowing Crayfish
- GA · *Clemmys guttata* Spotted Turtle
- *Cyprinella callisema* Ocmulgee Shiner
- *Hemidactylium scutatum* Four-toed Salamander
- GA · *Moxostoma robustum* Robust Redhorse
- *Myotis austroriparius* Southeastern Myotis
- US · *Picoides borealis* Red-cockaded Woodpecker
- *Pteronotropis hypselopterus* Sailfin Shiner

Plants

- *Astragalus michauxii* Sandhill Milkvetch
- GA · *Cuscuta harperi* Harper's Dodder
- GA · *Marshallia ramosa* Pineland Barbara Buttons
- *Pilularia americana* American Pillwort
- GA · *Schisandra glabra* Bay Starvine
- GA · *Stewartia malacodendron* Silky Camellia

Natural Communities

- *CAVE* Cave

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Locations of Special Concern Animals, Plants and Natural Communities in Jefferson County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of Information - 10/22/2004

Animals

- · *Acantharchus pomotis* Mud Sunfish
- GA · *Clemmys guttata* Spotted Turtle
- · *Cyprinella leedsi* Bannerfin Shiner
- GA · *Fusconaia masoni* Atlantic Pigtoe Mussel
- US · *Haliaeetus leucocephalus* Bald Eagle
- · *Heterodon simus* Southern Hognose Snake
- · *Necturus punctatus* Dwarf Waterdog
- · *Notropis chalybaeus* Ironcolor Shiner

Plants

- GA · *Nestronia umbellula* Indian Olive
- GA · *Penstemon dissectus* Grit Beardtongue
- US · *Sarracenia rubra* Sweet Pitcherplant

Natural Communities

No natural communities listed in Jefferson county.

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Locations of Special Concern Animals, Plants and Natural Communities in Screven County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of information - 10/22/2004

Animals

US · *Ambystoma cingulatum* Flatwoods Salamander
GA · *Clemmys guttata* Spotted Turtle
· *Crotalus adamanteus* Eastern Diamondback Rattlesnake
· *Cyprinella leedsi* Bannerfin Shiner
· *Cyprinella nivea* Whitefin Shiner
GA · *Elanoides forficatus* Swallow-tailed Kite
· *Etheostoma fricksium* Savannah Darter
· *Etheostoma serrifer* Sawcheek Darter
GA · *Fusconaia masoni* Atlantic Pigtoe Mussel
US · *Gopherus polyphemus* Gopher Tortoise
· *Heterodon simus* Southern Hognose Snake
US · *Mycteria americana* Wood Stork
· *Nerodia floridana* Florida Green Water Snake
GA · *Notophthalmus perstriatus* Striped Newt
· *Pseudacris brimleyi* Brimley's Chorus Frog
· *Pteronotropis hypselopterus* Sailfin Shiner
· *Rana capito* Gopher Frog
· *Scartomyzon sp. 1* Brassy Jumprock

Plants

· *Astragalus michauxii* Sandhill Milkvetch
· *Hypericum sp. 3* Georgia St. Jonhswort
US · *Lindera melissifolia* Pondberry
GA · *Litsea aestivalis* Pondspice
US · *Oxypolis canbyi* Canby's Dropwort
· *Quercus arkansana* Arkansas Oak
GA · *Sarracenia minor* Hooded Pitcherplant
· *Silene caroliniana* Carolina Pink
· *Sporobolus teretifolius* Wire-leaf Dropseed
GA · *Stewartia malacodendron* Silky Camellia

Natural Communities

- *CP MESIC BROADLEAF DECID.-BROADLEAF EVER. FOREST* Coastal Plain Mesic Ravine Forest
- *CP SPRING* Coastal Plain Spring
- *OPEN WATER/AQUATIC BED VEG., CAROLINA BAY* Open-water Carolina Bay

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Locations of Special Concern Animals, Plants and Natural Communities in Effingham County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants.

Date of Information - 10/22/2004

Animals

US · *Ambystoma cingulatum* Flatwoods Salamander
GA · *Clemmys guttata* Spotted Turtle
· *Condylura cristata* Star-nosed Mole
· *Cordulegaster sayi* Say's Spiketail
· *Cyprinella leedsi* Bannerfin Shiner
· *Cyprinella nivea* Whitefin Shiner
US · *Drymarchon couperi* Eastern Indigo Snake
GA · *Elanoides forficatus* Swallow-tailed Kite
· *Farancia erytrogramma* Rainbow Snake
US · *Gopherus polyphemus* Gopher Tortoise
· *Heterodon simus* Southern Hognose Snake
· *Menidia beryllina* Inland Silverside
· *Micrurus fulvius fulvius* Eastern Coral Snake
· *Necturus punctatus* Dwarf Waterdog
· *Ophisaurus attenuatus* Slender Glass Lizard
· *Ophisaurus mimicus* Mimic Glass Lizard
US · *Picoides borealis* Red-cockaded Woodpecker
· *Pituophis melanoleucus mugitus* Florida Pine Snake
· *Pseudacris brimleyi* Brimley's Chorus Frog
· *Pseudobranchus striatus* Dwarf Siren
· *Rana virgatipes* Carpenter Frog
· *Scartomyzon sp. 1* Brassy Jumprock
· *Seminatrix pygaea* Black Swamp Snake
· *Troglodytes troglodytes* Winter Wren

Plants

GA · *Epidendrum conopseum* Green-fly Orchid
· *Lachnocaulon beyrichianum* Southern Bog-button
US · *Lindera melissifolia* Pondberry
· *Listera australis* Southern Twayblade
GA · *Litsea aestivalis* Pondspice

- *Peltandra sagittifolia* Arrow Arum

GA · *Sarracenia flava* Yellow Flytrap

- *Silene caroliniana* Carolina Pink

GA · *Stewartia malacodendron* Silky Camellia

Natural Communities

- *BLACKWATER STREAM FLOODPLAIN FOREST* Blackwater Swamp

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Locations of Special Concern Animals, Plants and Natural Communities in Chatham County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of Information - 10/22/2004

Animals

US · *Acipenser brevirostrum* Shortnose Sturgeon
US · *Ambystoma cingulatum* Flatwoods Salamander
US · *Ammodramus maritimus* Seaside Sparrow
US · *Caretta caretta* Loggerhead
US · *Charadrius melodus* Piping Plover
GA · *Charadrius wilsonia* Wilson's Plover
US · *Chelonia mydas* Green Sea Turtle
GA · *Clemmys guttata* Spotted Turtle
· *Cyprinella leedsi* Bannerfin Shiner
US · *Dermochelys coriacea* Leatherback Sea Turtle
US · *Eubalaena glacialis* Northern Right Whale
US · *Gopherus polyphemus* Gopher Tortoise
GA · *Haematopus palliatus* American Oystercatcher
US · *Haliaeetus leucocephalus* Bald Eagle
US · *Himantopus mexicanus* Black-necked Stilt
US · *Lepidochelys kempii* Kemp's Or Atlantic Ridley
· *Menidia beryllina* Inland Silverside
US · *Mycteria americana* Wood Stork
· *Nyctanassa violacea* Yellow-crowned Night-heron
· *Nycticorax nycticorax* Black-crowned Night-heron
· *Petromyzon marinus* Sea Lamprey
US · *Picoides borealis* Red-cockaded Woodpecker
· *Pseudacris brimleyi* Brimley's Chorus Frog
· *Pseudorca crassidens* False Killer Whale
· *Rana capito* Gopher Frog
· *Rynchops niger* Black Skimmer
US · *Sterna antillarum* Least Tern
US · *Trichechus manatus* Manatee
· *Tyrannus dominicensis* Gray Kingbird

Plants

- *Forestiera segregata* Florida Privet
- *Hibiscus grandiflorus* Swamp Hibiscus

US · *Lindera melissifolia* Pondberry

GA · *Physostegia leptophylla* Tidal Marsh Obedient Plant

- *Rhynchospora punctata* Pineland Beaksedge
- *Sapindus saponaria* Soapberry

GA · *Sarracenia minor* Hooded Pitcherplant

- *Scutellaria mellichampii* Skullcap
- *Sporobolus pinetorum* Pineland Dropseed
- *Vigna luteola* Wild Yellow Cowpea

Natural Communities

No natural communities listed in Chatham county.

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Locations of Special Concern Animals, Plants and Natural Communities in Bryan County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of Information - 10/22/200

Animals

- *Acantharchus pomotis* Mud Sunfish
- US · *Acipenser brevirostrum* Shortnose Sturgeon
- GA · *Aimophila aestivalis* Bachman's Sparrow
- US · *Ambystoma cingulatum* Flatwoods Salamander
- US · *Caretta caretta* Loggerhead
- GA · *Clemmys guttata* Spotted Turtle
- *Crotalus adamanteus* Eastern Diamondback Rattlesnake
- *Cyprinella leedsi* Bannerfin Shiner
- US · *Drymarchon couperi* Eastern Indigo Snake
- GA · *Elanoides forficatus* Swallow-tailed Kite
- US · *Eubalaena glacialis* Northern Right Whale
- US · *Eumeces egregius* Mole Skink
- *Farancia erytrogramma* Rainbow Snake
- US · *Gopherus polyphemus* Gopher Tortoise
- US · *Haliaeetus leucocephalus* Bald Eagle
- *Heterodon simus* Southern Hognose Snake
- *Micrurus fulvius fulvius* Eastern Coral Snake
- GA · *Notophthalmus perstriatus* Striped Newt
- *Nyctanassa violacea* Yellow-crowned Night-heron
- *Ophisaurus attenuatus* Slender Glass Lizard
- US · *Picoides borealis* Red-cockaded Woodpecker
- *Pituophis melanoleucus mugitus* Florida Pine Snake
- *Pseudobranchus striatus* Dwarf Siren
- *Rana capito* Gopher Frog
- *Rana virgatipes* Carpenter Frog
- *Seminatrix pygaea* Black Swamp Snake
- US · *Trichechus manatus* Manatee
- *Umbra pygmaea* Eastern Mudminnow

Plants

- *Amorpha georgiana var. georgiana* Georgia Indigo-bush

GA · *Elliottia racemosa* Georgia Plume
GA · *Epidendrum conopseum* Green-fly Orchid
· *Illicium parviflorum* Yellow Anise-tree
· *Liatris pauciflora* Few-flower Gay-feather
GA · *Litsea aestivalis* Pondspice
· *Malaxis spicata* Florida Adders-mouth
· *Mikania cordifolia* Heartleaf Climbing Hempweed
GA · *Physostegia leptophylla* Tidal Marsh Obedient Plant
· *Platanthera nivea* Snowy Orchid
· *Ponthieva racemosa* Shadow-witch Orchid
· *Rhynchospora torreyana* Torrey Beakrush
GA · *Sarracenia minor* Hooded Pitcherplant
GA · *Stewartia malacodendron* Silky Camellia
· *Zenobia pulverulenta* Zenobia

Natural Communities

No natural communities listed in Bryan county.

NOTE: This is a working list and is constantly revised (see element occurance data disclaimer). For the latest changes, acknowledgment of numerous sources, interpretation of data, or other information connected with this list, please contact:

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Locations of Special Concern Animals, Plants and Natural Communities in Liberty County, Georgia

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"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of information - 10/22/2004

Animals

- *Acantharchus pomotis* Mud Sunfish
- GA · *Aimophila aestivalis* Bachman's Sparrow
- US · *Ambystoma cingulatum* Flatwoods Salamander
- US · *Caretta caretta* Loggerhead
- US · *Charadrius melodus* Piping Plover
- GA · *Charadrius wilsonia* Wilson's Plover
- GA · *Clemmys guttata* Spotted Turtle
- *Cordulegaster sayi* Say's Spiketail
- GA · *Corynorhinus rafinesquii* Rafinesque's Big-eared Bat
- *Cyprinella leedsi* Bannerfin Shiner
- US · *Drymarchon couperi* Eastern Indigo Snake
- US · *Eubalaena glacialis* Northern Right Whale
- *Farancia erytrogramma* Rainbow Snake
- *Fundulus chrysotus* Golden Topminnow
- US · *Gopherus polyphemus* Gopher Tortoise
- US · *Haliaeetus leucocephalus* Bald Eagle
- *Heterodon simus* Southern Hognose Snake
- *Micrurus fulvius fulvius* Eastern Coral Snake
- US · *Mycteria americana* Wood Stork
- GA · *Notophthalmus perstriatus* Striped Newt
- *Ophisaurus attenuatus* Slender Glass Lizard
- *Ophisaurus mimicus* Mimic Glass Lizard
- US · *Picoides borealis* Red-cockaded Woodpecker
- *Pituophis melanoleucus mugitus* Florida Pine Snake
- *Pseudobranchus striatus* Dwarf Siren
- *Rana capito* Gopher Frog
- *Rana virgatipes* Carpenter Frog
- *Seminatrix pygaea* Black Swamp Snake
- US · *Trichechus manatus* Manatee
- *Umbra pygmaea* Eastern Mudminnow

Plants

- *Agalinis aphylla* Scale-leaf Purple Foxglove
- GA · *Balduina atropurpurea* Purple Honeycomb Head
- GA · *Carex dasycarpa* Velvet Sedge
- *Eleocharis montevidensis* Spikerush
- GA · *Epidendrum conopseum* Green-fly Orchid
- *Habenaria quinqueseta var. quinqueseta* Michaux Orchid
- *Lobelia boykinii* Boykin Lobelia
- *Pteroglossaspis ecristata* Wild Coco
- *Quercus chapmanii* Chapman Oak
- *Rhynchospora torreyana* Torrey Beakrush
- *Sapindus saponaria* Soapberry
- GA · *Sarracenia minor* Hooded Pitcherplant
- *Scutellaria mellichampii* Skullcap
- GA · *Sideroxylon thornei* Swamp Buckthorn
- *Sporobolus pinetorum* Pineland Dropseed
- GA · *Stewartia malacodendron* Silky Camellia

Natural Communities

No natural communities listed in Liberty county.

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Locations of Special Concern Animals, Plants and Natural Communities in Long County, Georgia

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"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of information - 10/22/2004

Animals

- *Acantharchus pomotis* Mud Sunfish
- US · *Acipenser brevirostrum* Shortnose Sturgeon
- GA · *Aimophila aestivalis* Bachman's Sparrow
- *Alasmidonta arcula* Altamaha Arcmussel
- US · *Ambystoma cingulatum* Flatwoods Salamander
- GA · *Clemmys guttata* Spotted Turtle
- *Crotalus adamanteus* Eastern Diamondback Rattlesnake
- *Cyprinella callisema* Ocmulgee Shiner
- *Cyprinella leedsi* Bannerfin Shiner
- US · *Drymarchon couperi* Eastern Indigo Snake
- GA · *Elanoides forficatus* Swallow-tailed Kite
- *Elliptio dariensis* Georgia Elephantear
- US · *Elliptio spinosa* Altamaha Spinymussel
- US · *Eumeces egregius* Mole Skink
- *Falco sparverius paulus* Southeastern American Kestrel
- *Farancia erytrogramma* Rainbow Snake
- *Fundulus chrysotus* Golden Topminnow
- US · *Gopherus polyphemus* Gopher Tortoise
- US · *Haliaeetus leucocephalus* Bald Eagle
- *Hybognathus regius* Eastern Silvery Minnow
- *Lampropeltis triangulum triangulum* Eastern Milk Snake
- *Micrurus fulvius fulvius* Eastern Coral Snake
- US · *Mycteria americana* Wood Stork
- GA · *Notophthalmus perstriatus* Striped Newt
- *Nycticorax nycticorax* Black-crowned Night-heron
- *Ophisaurus attenuatus* Slender Glass Lizard
- *Ophisaurus compressus* Island Glass Lizard
- *Ophisaurus mimicus* Mimic Glass Lizard
- US · *Picoides borealis* Red-cockaded Woodpecker
- *Pituophis melanoleucus mugitus* Florida Pine Snake
- *Pseudobranchus striatus* Dwarf Siren
- *Pyganodon gibbosa* Inflated Floater

- *Rana capito* Gopher Frog
- *Rana virgatipes* Carpenter Frog
- *Sciurus niger shermani* Sherman's Fox Squirrel
- *Seminatrix pygaea* Black Swamp Snake

US · *Vermivora bachmanii* Bachman's Warbler

Plants

GA · *Balduina atropurpurea* Purple Honeycomb Head
- *Calopogon multiflorus* Many-flowered Grass-pink

GA · *Carex dasycarpa* Velvet Sedge
- *Dalea feayi* Feay Pink-tassels

GA · *Elliottia racemosa* Georgia Plume
GA · *Epidendrum conopseum* Green-fly Orchid
GA · *Fothergilla gardenii* Dwarf Witch-alder
- *Ilex amelanchier* Serviceberry Holly
- *Ipomoea macrorhiza* Large-stem Morning-glory
- *Liatris pauciflora* Few-flower Gay-feather

GA · *Litsea aestivalis* Pondspice
- *Lobelia boykinii* Boykin Lobelia

GA · *Matelea pubiflora* Trailing Milkvine
- *Peltandra sagittifolia* Arrow Arum

GA · *Penstemon dissectus* Grit Beardtongue
- *Plantago sparsiflora* Pineland Plantain
- *Platanthera nivea* Snowy Orchid
- *Pteroglossaspis ecristata* Wild Coco
- *Quercus austrina* Bluff White Oak

GA · *Sarracenia flava* Yellow Flytrap
GA · *Sarracenia minor* Hooded Pitcherplant
- *Sideroxylon sp. 1* Ohoopee Bumelia
- *Sporobolus pinetorum* Pineland Dropseed

Natural Communities

No natural communities listed in Long county.

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Locations of Special Concern Animals, Plants and Natural Communities in McIntosh County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of information - 10/22/2004

Animals

US · *Acipenser brevirostrum* Shortnose Sturgeon
GA · *Aimophila aestivalis* Bachman's Sparrow
US · *Ambystoma cingulatum* Flatwoods Salamander
· *Aramus guarauna* Limpkin
US · *Caretta caretta* Loggerhead
US · *Charadrius melodus* Piping Plover
GA · *Charadrius wilsonia* Wilson's Plover
GA · *Clemmys guttata* Spotted Turtle
GA · *Corynorhinus rafinesquii* Rafinesque's Big-eared Bat
· *Cyprinella callisema* Ocmulgee Shiner
· *Cyprinella leedsi* Bannerfin Shiner
US · *Dermochelys coriacea* Leatherback Sea Turtle
· *Dormitator maculatus* Fat Sleeper
US · *Drymarchon couperi* Eastern Indigo Snake
GA · *Elanoides forficatus* Swallow-tailed Kite
US · *Elliptio spinosa* Altamaha Spinymussel
US · *Eubalaena glacialis* Northern Right Whale
· *Farancia erytrogramma* Rainbow Snake
· *Fundulus chrysotus* Golden Topminnow
US · *Gopherus polyphemus* Gopher Tortoise
GA · *Haematopus palliatus* American Oystercatcher
US · *Haliaeetus leucocephalus* Bald Eagle
US · *Himantopus mexicanus* Black-necked Stilt
· *Hybognathus regius* Eastern Silvery Minnow
· *Lampropeltis triangulum triangulum* Eastern Milk Snake
GA · *Lucania goodei* Bluefin Killifish
· *Micrurus fulvius fulvius* Eastern Coral Snake
US · *Mycteria americana* Wood Stork
· *Myotis austroriparius* Southeastern Myotis
· *Nycticorax nycticorax* Black-crowned Night-heron
· *Ophisaurus compressus* Island Glass Lizard
· *Ophisaurus mimicus* Mimic Glass Lizard

- *Plegadis falcinellus* Glossy Ibis
- *Rana capito* Gopher Frog
- *Rynchops niger* Black Skimmer
- *Sciurus niger shermani* Sherman's Fox Squirrel

US · *Sterna antillarum* Least Tern
GA · *Sterna nilotica* Gull-billed Tern
US · *Trichechus manatus* Manatee

Plants

- *Acacia farnesiana* Sweet Acacia
- *Aeschynomene viscidula* Sticky Joint-vetch
- *Asclepias pedicellata* Savanna Milkweed

GA · *Carex dasycarpa* Velvet Sedge

- *Dalea feayi* Feay Pink-tassels
- *Dicerandra radfordiana* Radford Dicerandra

GA · *Epidendrum conopseum* Green-fly Orchid

- *Forestiera segregata* Florida Privet
- *Franklinia alatamaha* Franklin Tree
- *Hibiscus grandiflorus* Swamp Hibiscus
- *Hypericum denticulatum var. denticulatum* St. Johnswort
- *Hypericum sp. 3* Georgia St. Jonhswort
- *Leitneria floridana* Corkwood

GA · *Litsea aestivalis* Pondspice
GA · *Matelea pubiflora* Trailing Milkvine

- *Palafoxia integrifolia* Palafoxia

GA · *Physostegia leptophylla* Tidal Marsh Obedient Plant

- *Plantago sparsiflora* Pineland Plantain
- *Polygonum glaucum* Sea-beach Knotweed
- *Pteroglossaspis ecristata* Wild Coco
- *Quercus austrina* Bluff White Oak
- *Quercus chapmanii* Chapman Oak
- *Rhynchospora decurrens* Swamp-forest Beaksedge
- *Ruellia noctiflora* Night-blooming Wild Petunia

GA · *Sageretia minutiflora* Tiny-leaf Buckthorn

- *Sapindus saponaria* Soapberry

GA · *Sarracenia minor* Hooded Pitcherplant

- *Tephrosia chrysophylla* Sprawling Goats Rue
- *Tillandsia bartramii* Bartram's Air-plant
- *Vigna luteola* Wild Yellow Cowpea

Natural Communities

No natural communities listed in McIntosh county.

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Locations of Special Concern Animals, Plants and Natural Communities in Glynn County, Georgia

"US" indicates species with federal status (Protected, Candidate or Partial Status). Species that are federally protected in Georgia are also state protected.
"GA" indicates Georgia protected species.

Find details for the species below on our special concern lists for animals and plants. Date of Information - 10/22/2004

Animals

US · *Acipenser brevirostrum* Shortnose Sturgeon
· *Ammodramus henslowii* Henslow's Sparrow
· *Aramus guarauna* Limpkin
US · *Caretta caretta* Loggerhead
US · *Charadrius melodus* Piping Plover
GA · *Charadrius wilsonia* Wilson's Plover
US · *Chelonia mydas* Green Sea Turtle
· *Cyprinella leedsi* Bannerfin Shiner
US · *Dermochelys coriacea* Leatherback Sea Turtle
US · *Drymarchon couperi* Eastern Indigo Snake
GA · *Elanoides forficatus* Swallow-tailed Kite
US · *Eubalaena glacialis* Northern Right Whale
· *Farancia erytrogramma* Rainbow Snake
US · *Gopherus polyphemus* Gopher Tortoise
GA · *Haematopus palliatus* American Oystercatcher
US · *Haliaeetus leucocephalus* Bald Eagle
US · *Himantopus mexicanus* Black-necked Stilt
· *Lampropeltis triangulum triangulum* Eastern Milk Snake
US · *Lepidochelys kempii* Kemp's Or Atlantic Ridley
· *Menidia beryllina* Inland Silverside
· *Micrurus fulvius fulvius* Eastern Coral Snake
US · *Mycteria americana* Wood Stork
· *Myotis austroriparius* Southeastern Myotis
· *Ophisaurus compressus* Island Glass Lizard
· *Rynchops niger* Black Skimmer
US · *Sterna antillarum* Least Tern
GA · *Sterna nilotica* Gull-billed Tern
US · *Trichechus manatus* Manatee
· *Tyrannus dominicensis* Gray Kingbird

Plants

- *Agalinis divaricata* Pineland Purple Foxglove
- *Asclepias pedicellata* Savanna Milkweed
- *Carex decomposita* Cypress-knee Sedge
- *Coreopsis integrifolia* Tickseed
- *Eleocharis albida* White Spikerush

GA · *Epidendrum conopseum* Green-fly Orchid

- *Forestiera segregata* Florida Privet
- *Hibiscus grandiflorus* Swamp Hibiscus
- *Leitneria floridana* Corkwood

GA · *Litsea aestivalis* Pondspice

- *Palafoxia integrifolia* Palafoxia
- *Peltandra sagittifolia* Arrow Arum
- *Piloblephis rigida* Pennyroyal
- *Plantago sparsiflora* Pineland Plantain
- *Polygala balduinii* White Milkwort
- *Psilotum nudum* Whisk Fern
- *Quercus austrina* Bluff White Oak
- *Quercus chapmanii* Chapman Oak

GA · *Sageretia minutiflora* Tiny-leaf Buckthorn

GA · *Sarracenia minor* Hooded Pitcherplant

- *Thalia dealbata* Flag
- *Tillandsia bartramii* Bartram's Air-plant

GA · *Tillandsia recurvata* Ball-moss

- *Tillandsia setacea* Pine-needle Air-plant
- *Zamia integrifolia* Florida Coontie

Natural Communities

No natural communities listed in Glynn county.

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Special Concern Plant Species in Georgia

Date of information - 10/22/2004
660 plants on this list

Find details for the listed plants on NatureServe.

Scientific Name	Common Name	Global Rank (what's this?)	State Rank (what's this?)	Federal Status (what's this?)	State Status (what's this?)	Habitat in Georgia
Acacia farnesiana	Sweet Acacia	G5	SE1?			Sandy flats behind dunes; open live oak woods
Acer spicatum	Mountain Maple	G5	S2			High elevation boulder fields
Acorus americanus	Sweetflag	G5	S1S2			Okefenokee Swamp (?); seepy creekside with Xyris tenesseensis in Bartow Co.
Aeschynomene viscidula	Sticky Joint-vetch	G5?	S1?			Sandy pinelands; saltmarsh edges
Aesculus glabra	Ohio Buckeye	G5	S2			Mesic forests in circumneutral soil
Aesculus parviflora	Bottlebrush Buckeye	G2G3	S2S3			Mesic bluff and ravine forests
Agalinis aphylla	Scale-leaf Purple Foxglove	G3G4	S3?			Longleaf pine-wiregrass savannas; pine flatwoods
Agalinis decemloba	Purple Foxglove	G4Q	S1?			Dry, open woods over clays and sands
Agalinis divaricata	Pineland Purple Foxglove	G3?	S1?			Dry, grassy, pine-scrub oak ridges; extreme SW Georgia
Agalinis filicaulis	Spindly Purple Foxglove	G3G4	S2?			Seasonally wet, longleaf pine-wiregrass savannas; grassy pine barrens
Agalinis filifolia	Seminole Purple Foxglove	G4?	S1S2			Dry, sandy, longleaf pinelands
Agalinis tenuifolia var. leucanthera	Slender Purple Foxglove (white-flowered)	G5T?	SH			Savannas; open woodlands
Agarista populifolia	Pipe-stem Fetterbush	G4G5	SH			Swamps; hydric hammocks; marly spring runs
Agastache	Yellow Giant	G5	SH			Openings in rich

nepetoides	Hyssop					hardwoods
Agastache scrophulariifolia	Purple Giant Hyssop	G4	SH			Forested floodplains; river terraces
Agrimonia gryposepala	Hooked Harvest-lice	G5	S1?			Rich, circumneutral woodlands
Allium speculae	Flatrock Onion	G2	S2		T	Granite outcrops (limited to Lithonia Gneiss types)
Alnus maritima	Seaside Alder	G3	S1			Ridge and Valley spring runs in standing water
Amelanchier sanguinea	Roundleaf Serviceberry	G5	S1?			Rocky slopes
Amorpha georgiana var. georgiana	Georgia Indigo-bush	G3T2	S1			River terraces; floodplain woods; Flint Kaolin outcrops; mesic habitats with wiregrass,longleaf pine, mixed oaks
Amorpha herbacea var. floridana	Florida Leadbush	G4T?Q	S1			River terraces along the Alapaha River
Amorpha nitens	Shining Indigo-bush	G3?	S1?			Rocky, wooded slopes; alluvial woods
Amorpha schwerinii	Schwerin Indigo-bush	G3G4	S2			Rocky upland woods
Amphianthus pusillus	Pool Sprite	G2	S2	LT	T	Vernal pools on granite outcrops
Amsonia ludoviciana	Louisiana Blue Star	G3	S2			Open woods near granite outcrops (limited to Lithonia Gneiss types)
Andropogon brachystachyus	Shortspike Bluestem	G4	S1?			Wet flatwoods, pond margins and bogs
Andropogon longiberbis	Long-beard Bluestem	G5	S2?			Dry sandhills
Andropogon mohrii	Bog Bluestem	G4?	S2?			Longleaf pine-wiregrass savannas; pine-cypress savannas
Anemone berlandieri	Glade Windflower	G4?	S1S2			Granite outcrop ecotones; openings over basic rock

Anemone caroliniana	Carolina Windflower	G5	S1?			Upland seepage swamp openings over Iredell soils; wet meadows
Angelica dentata	Sandhill Angelica	G2G3	S2?			Longleaf pine-wiregrass savannas
Arabis georgiana	Georgia Rockcress	G1	S1	C	T	Rocky or sandy river bluffs and banks, in circumneutral soil
Arabis lyrata	Lyre-leaf Rockcress	G5	SH			Shaded rock bluffs
Arabis missouriensis	Missouri Rockcress	G5?Q	S2			Granite and amphibolite outcrops
Arabis patens	Spreading Rockcress	G3	SH			Wooded limestone slopes
Aralia nudicaulis	Wild Sarsaparilla	G5	S2?			Northern hardwood forests
Aristida gyrans	Corkscrew Three-awn Grass	G4G5	S1?			Dry sandy pinelands
Aristida simpliciflora	Chapman Three-awn Grass	G3G4	SH			Longleaf pine-wiregrass savannas
Armoracia lacustris	Lake-cress	G4?	S1?			Shallow water of swamps and lake margins
Arnoglossum diversifolium	Variable-leaf Indian-plantain	G2	S2		T	Calcareous swamps
Arnoglossum sulcatum	Grooved-stem Indian-plantain	G2G3	S1			Bottomland forests
Asclepias hirtella	Barrens Milkweed	G5	S2			Limestone glades; remnant prairies and nearby roadbanks
Asclepias pedicellata	Savanna Milkweed	G4	S2?			Longleaf pine flatwoods; sandy pinelands with longleaf pine-saw palmetto-myrtle oak (Sapelo Island)
Asclepias purpurascens	Purple Milkweed	G5?	S1			Calcareous flatwoods, wet meadows near Rome
Asclepias rubra	Red Milkweed	G4G5	SH			Bogs, wet savannas
Asimina pygmaea	Dwarf Pawpaw	G4	S1?			Flatwoods, wet

						savannas
Asimina reticulata	Netleaf Pawpaw	G4	S1			Flatwoods, wet savannas
Asplenium heterochroum	Varicolor Spleenwort	G3G5	SR			Limestone outcrops; marl
Asplenium heteroresiliens	Wagner's Spleenwort	G2Q	S1		T	Limestone and marl outcrops; tabby ruins
Asplenium ruta-muraria	Wall Rue Spleenwort	G5	S1			Limestone outcrops
Aster avitus	Alexander Rock Aster	G3	S3			Granite outcrops in seepy margins with Solidago gracillima and Spiranthes cernua
Aster ericoides	Heath Aster	G5	S1			Limestone glades
Aster eryngiifolius	Snakeroot-leaf Aster	G3G4	S1			Moist pinelands
Aster georgianus	Georgia Aster	G2G3	S2	C		Upland oak-hickory-pine forests and openings; sometimes with Echinacea laevigata or over amphibolite
Aster laevis var. laevis	Smooth Aster	G5T5	S2?			Mesic hardwood forests in circumneutral soil
Aster novae-angliae	New England Aster	G5	S1			Remnant prairies
Aster phlogifolius	Phlox-leaved Aster	G5T5	S1			Mesic hardwood forests over basic soil
Aster praealtus	Willow-leaf Aster	G5	S1?			Lowland forests over limestone
Astragalus canadensis	Canada Milkvetch	G5	S1			Hardwood forests over limestone
Astragalus michauxii	Sandhill Milkvetch	G3	S2			Longleaf pine-wiregrass savannas; turkey oak scrub
Astranthium integrifolium	Wild Daisy	G5	S1?			Limestone glades
Astrolepis sinuata ssp. sinuata	Wavy Cloak Fern	G5?T5?	SE1?			Granite outcrops and boulders
Aureolaria	Spreading	G3	S1			Circumneutral

patula	Yellow Foxglove					alluvial bottoms
Balduina atropurpurea	Purple Honeycomb Head	G2	S2		R	Wet savannas, pitcherplant bogs
Baptisia arachnifera	Hairy Rattleweed	G1	S1	LE	E	Pine flatwoods
Baptisia australis var. aberrans	Glade Blue Indigo	G5T2T3	S2			Limestone glades and barrens
Baptisia australis var. australis	Streamside Blue Indigo	G5T?	S1			Gravel bars
Baptisia lecontei	Leconte Wild Indigo	G4?	S1			Pineland scrub
Baptisia megacarpa	Bigpod Wild Indigo	G2	S1			Floodplain forests
Berberis canadensis	American Barberry	G3	S1			Cherty, thinly wooded slopes
Boltonia caroliniana	Carolina Boltonia	G4?	S1?			Moist lowlands, including wet prairies and flatwoods around Rome
Bouteloua curtipendula	Side-oats Grama	G5	S2			Limestone glades and barrens
Brachyelytrum septentrionale	Northern Shorthusk Grass	G4G5	S1			Rich, north-facing cove forests; moist, north-facing cliff ledges
Brachymenium systylium	Mexican Brachymenium	G5	S1?			Sandstone bluffs.
Brickellia cordifolia	Flyr's Nemesis	G2G3	S1			Mesic hardwood forests
Buchnera americana	Bluehearts	G5?	S1			Wet meadows; seasonally moist barrens and limestone glades
Calamagrostis porteri	Porter's Reedgrass	G4	S1			Base of north-facing, granitic cliffs
Calamintha ashei	Ohoopee Dunes Wild Basil	G3	S2		T	Ohoopee dunes
Callirhoe digitata	Finger Poppy-mallow	G4	SE1?			Open woods and relict prairies; enhanced locally along mowed rights-of-way over calcareous substrates of NW

					Georgia
Callirhoe papaver	Woods Poppy-mallow	G5	S2S3		Openings in oak-pine forests
Callirhoe triangulata	Clustered Poppy-mallow	G3	S2		Sandy scrub
Calopogon multiflorus	Many-flowered Grass-pink	G2G3	SH		Wet savannas; pitcherplant bogs
Calycanthus brockiana	Brock Sweetshrub	G1?Q	SU		Mesic hardwood forests
Calystegia catesbeiana ssp. catesbeiana	Catesby Bindweed	G3T2?Q	S1?		Longleaf pine-wiregrass savannas
Calystegia catesbeiana ssp. sericata	Silky Bindweed	G3T2T3Q	S2S3		Openings in montane oak-hickory-pine forests
Camassia scilloides	Wild Hyacinth	G4G5	S2		Floodplain and mesic hardwood forests over limestone
Campanula aparinoides	Marsh Bellflower	G5	S1?		Mountain bogs and wet meadows, sometimes with Polygonum sagittatum
Campylopus carolinae	Sandhill Awned Moss	G1G2	S2?		Fall line sandhills; Altamaha Grit outcrops in partial shade of mesic oak forests
Cardamine dissecta	Divided Toothwort (blue Ridge Populations)	G4?	S3		Rich, cove forests
Carex aestivaliformis	Sedge	G?Q	S1?		Upland submesic oak forests in Blue Ridge
Carex albursina	White Bear Lake Sedge	G5	S1		Rich, calcareous woods
Carex appalachica	Appalachian Sedge	G4	S1?		Dry to moist, rocky, open woods and heath balds
Carex baltzellii	Baltzell's Sedge	G3	S1	E	Beech-magnolia slope forests
Carex biltmoreana	Biltmore Sedge	G3	S1	T	High elevation ledges and rock faces
Carex	Sedge	G5	SH		High elevation

brunnescens					ledges and grass balds
Carex buxbaumii	Brown Bog Sedge	G5	SH		Sag ponds, peat bogs
Carex careyana	Carey Sedge	G4G5	S1		Mesic hardwood forests over limestone
Carex collinsii	Narrow-fruit Swamp Sedge	G4	S2		Seepage bogs; Atlantic whitecedar swamps; other habitats?
Carex dasycarpa	Velvet Sedge	G4?	S3	R	Evergreen hammocks; mesic hardwood forests
Carex decomposita	Cypress-knee Sedge	G3	S2?		Swamps and lake margins on floating logs
Carex eburnea	Black-seed Sedge	G5	S1		Limestone outcrops and ledges
Carex fissa var. aristata	Sedge	G3G4QT3T4	S1		Wet savannas
Carex floridana	Florida Sedge	G5?	S3		Sandy oak-hickory woods
Carex folliculata	Sedge	G4G5	S1		Mountain bogs
Carex grayi	Asa Gray Sedge	G4	S2S3		Calcareous meadows and alluvial woods
Carex hystericina	Porcupine Sedge	G5	S2?		Spring runs; wet meadows
Carex lucorum	Southern Fibrous Root Sedge	G4	S1?		Wet ledges in Tallulah Gorge
Carex manhartii	Manhart's Sedge	G3	S2S3	T	Cove hardwood forests; other mesic deciduous forests
Carex misera	Wretched Sedge	G3	S1	T	Grassy balds
Carex oligocarpa	Few-fruit Sedge	G4	S2?		Rich hardwood forests over limestone
Carex pedunculata	Longstalk Sedge	G5	S1?		Cove hardwood forests
Carex platyphylla	Broadleaf Sedge	G5	S1		Mesic hardwood forests over basic rock
Carex	Purple Sedge	G4?	S2	T	Mesic hardwood

purpurifera				forests over limestone
Carex radfordii	Radford Sedge	G2	S1?	Rich woods of marble ravines
Carex reniformis	Reniform Sedge	G4?	S1?	Cypress swamps, wet woods and sloughs
Carex roanensis	Roan Mountain Sedge	G2	S1	Boulderfields and exposed granite ledges
Carex rosea	Rosy Sedge	G5	S2?	Dryish hardwood forests
Carex scabrata	Sedge	G5	S2	High elevation boulderfields
Carex scoparia	Broom Sedge	G5	S1?	Bogs and marshes; seepy ledges
Carex seorsa	Weak Stellate Sedge	G4	S1?	Water tupelo swamps
Carex socialis	Social Sedge	G4	S1?	Alluvial floodplain woods, often with Carex intumescens
Carex stricta	Tussock Sedge	G5	S1	Sag ponds and other seasonal depression ponds
Carex torta	Twisted Sedge	G5	S1?	Rocky streambeds
Carex venusta var. minor	Sedge	G4T4	S2?	Floodplains and bottomlands, often with Peltandra virginica
Carex venusta var. venusta	A Sedge	G4T4?	S1?	Peat bogs; wet, mossy woods
Carex woodii	Sedge	G4	S1?	High elevation rock outcrops
Carphephorus bellidifolius	Sandy-woods Chaffhead	G4	S1?	Sandy scrub
Carphephorus pseudoliatris	Lavender Lady	G4G5	SH	Pine flatwoods
Carya laciniosa	Shellbark Hickory	G5	S2?	Bottomland forests
Carya myristiciformis	Nutmeg Hickory	G4	S1	Calcareous flatwoods
Castilleja coccinea	Scarlet Indian-paintbrush	G5	S2?	Open, rocky, chestnut oak woods
Cayaponia quinqueloba	Cayaponia	G4	S1	Swamp forests; sandy openings in floodplains and on riverbanks

Celastrus scandens	Bittersweet	G5	S2?			Open, rocky areas in thickets and deciduous forests
Cephaloziella obtusilobula	Roundleaf Leafy Liverwort	GHQ	SH			Moist cliff faces
Ceratiola ericoides	Rosemary	G4	S2		T	Ohoopee Dunes; deep sandridges
Chaerophyllum procumbens	Spreading Chervil	G5	S2			Low rich woods in circumneutral soil
Chamaecrista deeringiana	Florida Senna	G1G2	S1?			Sandhill scrub; longleaf pine-wiregrass savannas
Chamaecyparis thyoides	Atlantic White-cedar	G4	S2		R	Clearwater stream swamps in fall line sandhills
Cheilanthes alabamensis	Alabama Lipfern	G4G5	S2			Limestone ledges
Chelone cuthbertii	Cuthbert Turtlehead	G3	S1			Bogs and wet meadows
Chrysosplenium americanum	Golden Saxifrage	G5	S1			Pools in rocky montane streams
Cirsium carolinianum	Carolina Thistle	G5	S3			Prairies; open mixed pine-oak woods, shortleaf pine-blackjack oak savannas over serpentine
Cirsium lecontei	Leconte Thistle	G2G3	S1S3			Moist pinelands and savannas
Cirsium muticum	Swamp Thistle	G5	S1?			Remnant wet prairies
Cirsium virginianum	Virginia Thistle	G3	S2?			Moist pinelands; moist longleaf pine/wiregrass savannas
Cleistes bifaria	Spreading Pogonia	G4?	S1?			Mountain seeps and wet meadows
Clematis fremontii	Fremont's Virgin's-bower	G5				
Clematis ochroleuca	Curly-heads	G4	S2			Dry woods in circumneutral soil
Clematis socialis	Alabama Leather Flower	G1	S1	LE	E	Grassy openings in flatwoods of mostly lowland oaks and red maple
Clintonia borealis	Yellow Bead-lily	G5	SH			Northern hardwood forests

Comptonia peregrina	Sweet-fern	G5	S1		Disturbed areas and open upland forests
Corallorhiza maculata	Spotted Coralroot	G5	SH		High elevation hardwood forests; beech gaps
Coreopsis integrifolia	Tickseed	G1G2	S1S2		Floodplain forests, streambanks
Coreopsis latifolia	Broadleaf Tickseed	G3	S1		Mature deciduous forests with open understory
Cornus drummondii	Rough-leaved Dogwood	G5	S1?		Open woods and cedar glades over calcareous shale and limestone
Corydalis flavula	Yellow Corydalis	G5	S1?		Rocky floodplain forests; hardwood ravines over amphibolite or limestone
Corydalis sempervirens	Pale Corydalis	G4G5	S1		Montane ledges and rocky summits
Cotinus obovatus	American Smoketree	G4	S1		Mixed oak-redcedar forests on rocky limestone slopes
Crataegus brachyacantha	Blueberry Hawthorn	G4	SH		Open pinelands
Crataegus pulcherrima	Beautiful Haw	G2G4	S1?		Rich, open deciduous woods and edges
Crataegus triflora	Three-flower Hawthorn	G2	S1		Hardwood forests on rocky, limestone slopes
Croomia pauciflora	Croomia	G3	S1	T	Mesic hardwood forests, usually with Fagus and Tilia
Croton elliottii	Elliott Croton	G2G3	S2S3		Pond margins and wet savannas
Ctenium floridanum	Florida Orange-grass	G2	S1		Moist pine barrens
Cuscuta harperi	Harper's Dodder	G2	S1	T	Altamaha Grit outcrops; granite outcrops; often with Liatris microcephala as host

Cuscuta rostrata	Beaked Dodder	G4	SH		High elevation hardwood forests
Cymophyllus fraserianus	Fraser's Sedge	G4	S1	T	Mixed hardwood-hemlock forests
Cyperus flavicomus	Whiteedge Flatsedge	G5	SE1?		Moist to wet ditches; marshes
Cyperus lupulinus ssp. macilentus	Meagre Hop Flatsedge	G5T5?	S1?		Dry, open pinelands?
Cyperus thyrsiflorus	Thyrsoid Flatsedge	G5	S1?		Wet streambanks and swamps
Cypripedium acaule	Pink Ladyslipper	G5	S4	U	Upland oak-hickory-pine forests; piney woods
Cypripedium kentuckiense	Kentucky Ladyslipper	G3	S1		Forested, springhead seeps in sandy soils
Cypripedium parviflorum var. parviflorum	Small-flowered Yellow Ladyslipper	G5T3T4	S3?	U	Upland oak-hickory-pine forests; mixed hardwood forests
Cypripedium parviflorum var. pubescens	Large-flowered Yellow Ladyslipper	G5T5	S3	U	Upland oak-hickory-pine forests; mixed hardwood forests
Cystopteris tennesseensis	Tennessee Fragile Fern	G5	S1		Seepy limestone-shale outcrops
Dalea candida	Prairie Clover	G5	S1		Limestone glades and barrens
Dalea carnea var. carnea	Pink-tassels	G5T3T4	S1?		Dry, sandy pinelands
Dalea carnea var. gracilis	Sprawling White-tassels	G5T3T4	SH		Wet pine savannas, Southwest Georgia
Dalea feayi	Feay Pink-tassels	G4G5	S1		Dry pinelands and scrub
Dalea gattingeri	Gattinger Prairie Clover	G3G4	S2S3		Limestone glades and barrens
Danthonia epilis	Bog Oat-grass	G3G4	S1?		Mountain bogs
Dasistoma macrophylla	Mullein Foxglove	G4	S1?		Rocky limestone woods
Delphinium carolinianum ssp. calciphilum	Glade Larkspur	G5T2T4	S2		Limestone glades
Delphinium tricorne	Dwarf Larkspur	G5	S2?		Mesic hardwood forests in calcareous areas

Desmodium ochroleucum	Creamflower Tick-trefoil	G1G2	S1			Open, calcareous woodlands, including lower slope of Pigeon Mountain
Desmodium sessilifolium	Sessile-leaf Tick-trefoil	G5	S1?			Sandhills in oak forest openings; perhaps prairie relict areas?
Diarrhena americana	American Dropseed	G4?	S1			Mesic hardwoods over limestone
Dicentra canadensis	Squirrel-corn	G5	S1?			Mesic hardwood forests
Dicentra eximia	Bleeding Heart	G4	S1			Montane ledges and rocky slopes
Dicerandra radfordiana	Radford Dicerandra	G1Q	S1			Sandridges
Diervilla lonicera	Northern Bush-honeysuckle	G5	S1?			Rocky bluffs
Diphasiastrum tristachyum	Ground Cedar	G5	S1			Rocky ledges; upland forests
Draba aprica	Open-ground Whitlow-grass	G3	S1S2		E	Granite and amphibolite outcrops, usually in redcedar litter
Drosera rotundifolia	Roundleaf Sundew	G5	S1?			Seepy montane ledges and sphagnum bogs
Drosera tracyi	Tracy's Dew-threads	G3G4	S1			Pitcherplant bogs; grassy seepage slopes
Dryopteris carthusiana	Spinulose Shield Fern	G5	S1			Strongly sloping, high altitude granitic outcrop
Dryopteris celsa	Log Fern	G4	S2			Floodplain forests; lower slopes of rocky woods
Dryopteris cristata	Crested Wood Fern	G5	SE1?			Swamps
Echinacea laevigata	Smooth Purple Coneflower	G2	S2	LE	E	Upland forests over amphibolite
Echinacea pallida	Pale Purple Coneflower	G4	SE1?			Prairies; perhaps longleaf pine/wiregrass savannas
Echinacea purpurea	Purple Coneflower	G4	S2?			Prairies and glades, circumneutral soils
Echinacea	Prairie Purple	G3	S2S3			Remnant prairies in

simulata	Coneflower					the Coosa flatwoods near Rome
Echinodorus parvulus	Dwarf Burhead	G3Q	S1?			Shallow pools; limesink depression ponds
Elatine triandra	Longstem Waterwort	G5	SE1?			Old quarry pools on granite outcrops
Eleocharis albida	White Spikerush	G4G5	S2S3			Brackish pools
Eleocharis atropurpurea	Spikerush	G4G5	S1S3			Limesink pond margins
Eleocharis compressa	Spikerush	G4	S2S3			Limestone glades and barrens
Eleocharis erythropoda	Spikerush	G5	S1?			Sag pond margins
Eleocharis fallax	Spikerush	G4G5	S1?			Brackish marsh
Eleocharis montana	Nodose Spikerush	G5	SH			Marshy shores and peaty depressions on heavy clay soils
Eleocharis montevidensis	Spikerush	G5	S1			Wet sands on barrier islands; maritime wet grasslands
Eleocharis tenuis var. verrucosa	Warty Slender Spikerush	G5T3T5	S2?			Muddy banks of small streams in Coosa Flatwoods
Eleocharis wolfii	Spikerush	G3?	S1			Shallow pools on granite outcrops
Elliottia racemosa	Georgia Plume	G2G3	S2S3		T	Scrub forests; Altamaha Grit outcrops; open forests over ultramafic rock
Elyonurus tripsacoides	Pan-american Balsamscale	G5?	SH			Pine savannas
Epidendrum conopseum	Green-fly Orchid	G4	S3		U	Epiphytic on limbs of evergreen hardwoods; also in crevices of Altamaha Grit outcrops
Erigenia bulbosa	Harbinger-of-spring	G5	S1			Mesic hardwood forests over basic soils
Erigeron strigosus var. calcicola	Cedar Glade Daisy Fleabane	G5T3	S1			LIMESTONE GLADES OR CEDAR GLADES

Eriocaulon koernickianum	Dwarf Pipewort	G2	S1		Granite outcrops
Eriocaulon texense	Texas Pipewort	G4	S2?		Altamaha grit outcrops; wet pine savannas
Eriochloa michauxii var. michauxii	Michaux's Cupgrass	G3G4T3T4	S2?		Coastal freshwater and brackish marshes; flatwoods
Eriophorum virginicum	Tawny Cotton-grass	G5	S1		Mountain bogs; peaty wet meadows in alluvial flats in Fall Line sandills; also in Okefenokee Swamp
Eupatorium godfreyanum	Godfrey's Eupatorium	G4	S1?		Upland, open woods in circumneutral soils
Eustachys floridana	Florida Finger Grass	G2?	S1?		Sandhills and flatwoods
Evolvulus sericeus var. sericeus	Creeping Morning-glory	G5T3T5	S1	E	Altamaha Grit outcrops; open calcareous uplands
Fimbristylis brevivaginata	Flatrock Fimbry	G2	S2		Granite outcrops
Fimbristylis perpusilla	Harper's Fimbry	G2	S1	E	Exposed muddy margins of pineland ponds
Forestiera godfreyi	Godfrey Privet	G2	S1		Mesic, maritime forests over shell mounds
Forestiera segregata	Florida Privet	G4	S2		Shell mounds on barrier islands in scrub or maritime forests
Fothergilla gardenii	Dwarf Witch-alder	G3G4	S2	T	Openings in low woods; swamps
Fothergilla major	Mountain Witch-alder	G3	S1		Rocky (sandstone, granite) woods; bouldery stream margins
Franklinia alatamaha	Franklin Tree	GXC	SX		Sandridges
Fraxinus quadrangulata	Blue Ash	G5	S1S2		Mesic hardwood forests over limestone
Frullania appalachiana	A Liverwort	G1?	S1		On tree trunks and decaying wood above 3800 ft.

Fuirena longa	Umbrella Sedge	G3G4	SE1?			Pond margins near the coast; perhaps introduced when planting maidencane (Panicum hemitomon) plugs
Fuirena scirpoidea	Southern Umbrella-sedge	G5	S1?			Pineland depressions, wet savannas with Toxicodendron vernix; often in maintained rights-of-way
Galactia floridana	Florida Milk-pea	G3G4	S1?			Pine flatwoods
Gentianopsis crinita	Fringed Gentian	G5	S1		T	Wet meadows and grassy roadsides over circumneutral soils
Glandularia bipinnatifida	Dakota Vervain	G5	S1			Dry prairies, as the gumbo white clay (Black Belt) openings on the Fort Valley Plateau
Glyceria acutiflora	Sharp-scaled Manna-grass	G5	S1?			Sag pond margins
Glyceria melicaria	Slender Manna-grass	G5	S1?			Swamps
Glyceria pallida	Pale Manna-grass	G5?	SH			Shallow water of sag ponds
Glyceria septentrionalis	Floating Manna-grass	G5	S1?			Cypress ponds with Hymenocallis choctawensis and Iris brevicaulis; large river floodplain sloughs
Gymnocolea inflata	A Liverwort	G5	S1			In spray zones of waterfalls, Altamaha grit outcrops.
Gymnoderma lineare	Rock Gnome Lichen	G2	S1	LE	E	Moist cliff faces
Gymnopogon brevifolius	Broad-leaved Beardgrass	G5	S2?			Calcareous glades and relict prairies; dryish clay-loam soils
Gymnopogon chapmanianus	Chapman Skeleton Grass	G3	SH			Sandy pinelands near Florida,

						perhaps with Ctenium floridanum
Habenaria quinqueseta var. quinqueseta	Michaux Orchid	G4G5T?	S1			Moist shade, Altamaha Grit outcrops; open pine woods
Hartwrightia floridana	Hartwrightia	G2	S1		T	Wet savannas; ditches, sloughs and flatwood seeps
Helenium brevifolium	Bog Sneezeweed	G3G4	S1			Seepage bogs, sometimes with Sarracenia rubra near the Fall Line
Helianthemum bicknellii	Hoary Frostweed	G5	SU			Dry, sandy, open upland forests
Helianthemum canadense	Canadian Frostweed	G5	S1?			Dry, sandy scrub in fire-suppressed longleaf pine forest
Helianthus agrestis	Southeastern Sunflower	G4?	SH			Mucky, wet soils in open flatwoods
Helianthus glaucophyllus		G3	S1			Open, oak-hickory woods above 2500 ft.
Helianthus heterophyllus	Wetland Sunflower	G4	S1			Bogs; wet pine savannas
Helianthus occidentalis	Barrens Sunflower	G5	S1?			Limestone glades and barrens; rocky or cherty soils
Helianthus smithii	Smith Sunflower	G2Q	S1			Dry open woods and thickets
Helianthus verticillatus	Whorled Sunflower	G1Q	S1	C		Remnant prairies
Heliotropium tenellum	Delicate Heliotrope	G5	S2?			Limestone glades and barrens
Helonias bullata	Swamp-pink	G3	S1	LT	T	Open swamps
Heracleum lanatum	Masterwort, Giant Parsnip	G5	S1			Northern hardwood forests and open oak forests
Herpetineuron toccoae	A Moss	G4G5	S1?			Appalachian Trail (1999), on rock in mesophytic forests.
Hexastylis shuttleworthii var. harperi	Harper's Heartleaf	G4T3	S2S3		U	Low terraces in floodplain forests; edges of bogs
Hibiscus grandiflorus	Swamp Hibiscus	G4?	SH			Tidal marshes, coastal flatwoods; wet savannas

Hieracium scabrum	Rough Hawkweed	G5	S2?		Upland forests; dry sandy soils
Hottonia inflata	Featherfoil	G4	S1		Sag ponds
Huperzia appalachiana	Fir Clubmoss	G4G5	S1		Seepy ledges at high elevations
Huperzia porophila	Rock Clubmoss	G4	S1		Seepy ledges
Hydrastis canadensis	Goldenseal	G4	S2	E	Rich woods in circumneutral soil
Hydrophyllum macrophyllum	Largeleaf Waterleaf	G5	S1		Rich woods in circumneutral soil
Hygrophila lacustris	Hygrophila	G5?	S1?		Shallow water of marshy shores
Hymenocallis coronaria	Shoals Spiderlily	G2Q	S2	E	Rocky shoals of broad, open rivers
Hymenophyllum tayloriae	Taylor Filmy Fern	G1G2	S1		Wet ledges along the Chattooga River
Hypericum adpressum	Bog St. Johnswort	G3	S2?		Swamps
Hypericum buckleii	Blue Ridge St. Johnswort	G3	S1		High elevation rocky crevices
Hypericum denticulatum var. denticulatum	St. Johnswort	G5T?Q	S1		Bogs, seeps, and moist pine savannas
Hypericum dolabriforme	Glade St. Johnswort	G4	S3		Limestone glades and barrens
Hypericum sp. 3	Georgia St. Jonhswort	G2G3	S2S3		seepage bogs; roadside ditches
Hypericum sphaerocarpum	Barrens St. Johnswort	G5	S1		Limestone barrens
Hypnum cupressiforme var. filiforme	A Moss	G5T?	S2?		Hanging as green threads from rocks or bark, perhaps above 3800 ft.
Ilex amelanchier	Serviceberry Holly	G4	S2		Wet, sandy thickets; cypress-gum swamps
Ilex cuthbertii	Cuthbert Holly	G1?	SH		Open, upland forests, circumneutral
Illicium floridanum	Florida Anise-tree	G5	S1	E	Steepheads, floodplain forests
Illicium parviflorum	Yellow Anise-tree	G2	SH		Evergreen hammocks, bayheads
Ipomoea	Large-stem	G3G5	S1?		Exposed sandy

macrorhiza	Morning-glory					soils
Iris brevicaulis	Lamance Iris	G4	S1			Bogs, seeps, marshy shores and floodplains; often hidden in taller vegetation due to its low stature
Iris tridentata	Savanna Iris	G3G4	S2?			Wet savannas, flatwoods, cypress pond margins
Isoetes appalachiana	Bigspore Engelmann's Quillwort	G4	S1			Shallow water (one foot deep) of slow moving streams; mucky stream margins, periodically droughty
Isoetes boomii	Boom Quillwort	G1	S1			Shallow water (one foot deep) of slow moving streams
Isoetes butleri	Glade Quillwort	G4	S1			Limestone glades
Isoetes hyemalis	Quillwort	G2G3	S1			In blackwater streams; also emergent on sandy creek banks in deciduous swamps
Isoetes junciformis	Rush Quillwort	G1?Q	S1?			Low, seasonally flooded swales
Isoetes melanopoda	Black-footed Quillwort	G5	S1?			Clayey soils in low woods; sandstone or granite outcrop seeps
Isoetes melanospora	Black-spored Quillwort	G1	S1	LE	E	Vernal pools on granite outcrops
Isoetes tegetiformans	Mat-forming Quillwort	G1	S1	LE	E	Vernal pools on granite outcrops
Isoetes valida	Carolina Quillwort	G4?	S1			North Georgia seeps, shallow pools, sluggish streams
Isotria medeoloides	Small Whorled Pogonia	G2	S2	LT	T	Mixed hardwood-pine forests with open understory; history of nearby heavy logging, homesite or road clearing activity
Jamesianthus alabamensis	Jamesianthus	G3	S1			Streambanks, in circumneutral soil

Jeffersonia diphylla	Twinleaf	G5	S1	E	Mesic deciduous forests over limestone
Juglans cinerea	Butternut (nut-bearing Only)	G3G4	S2		Openings in bottomland forests and in the mesophytic hardwood forests of rich mountain coves
Juncus filipendulus	Texas Plains Rush	G5	S2?		Remnant prairies; limestone barrens
Juncus gymnocarpus	Naked-fruit Rush	G4	S2S3		Seepy streamsides; open swamps; mountain bogs
Juniperus communis var. depressa	Ground Juniper	G5T5	S1		Gneiss ledges
Justicia angusta	Narrowleaf Water-willow	G3Q	SH		Roadside ditches; perhaps with Hartwrightia in shallow sloughs and wet savannas
Kalmia carolina	Carolina Bog Myrtle	G4	S1		Open swamps and wet meadows; mountain bogs and Atlantic white-cedar swamps
Lachnocaulon beyrichianum	Southern Bog-button	G2G3	S1		Flatwoods
Lathyrus palustris	Marsh Wild Pea	G5	S1?		Alluvial meadows, floodplain forests
Leavenworthia exigua var. exigua	Gladecress	G4T3	S2	T	Limestone glades
Leavenworthia uniflora	Gladecress	G4	S1		Limestone glades
Lechea deckertii	Deckert Pinweed	G4G5	S1?		Scrub
Leiophyllum buxifolium	Sand-myrtle	G4	S1		High altitude rocky ledges
Leitneria floridana	Corkwood	G3	S1		Swamps; sawgrass-cabbage palmetto marshes
Lejeunea blomquistii	Blomquist Leafy Liverwort	G1G2	SH		Waterfall spray zones
Leucothoe	Recurved Dog-	G4G5	S1		Rocky open upland

recurva	hobble					forests
Liatris chapmanii	Chapman Gay-feather	G5	SH			Scrub
Liatris pauciflora	Few-flower Gay-feather	G4G5	S2?			Sandridge scrub
Liatris secunda	Sandhill Gay-feather	G4G5	S1?			Fall line sandhills
Liatris squarrosa var. hirsuta	Glade Gay-feather	G5T4?	S2?			Glades and barrens over basic rock
Liatris tenuifolia var. quadriflora	Blazing Star	G4G5T4T5	S1?			Open oak or pine woods
Lilaeopsis carolinensis	Carolina Lilaeopsis	G3G5	SH			saltwater marshes and muddy shores
Lilium canadense	Canada Lily	G5	S2?			Openings in rich woods
Lilium michiganense	Michigan Lily	G5	S1			Remnant wet prairies and calcareous flatwoods
Lilium philadelphicum	Wood Lily	G5	S1			Wet meadows over sandstone
Lindera melissifolia	Pondberry	G2	S1	LE	E	Pond margins and wet savannas
Lindera subcoriacea	Bog Spicebush	G2	S1?			Bayheads; seepy forested slopes
Lindernia saxicola	Rock False Pimpernel	G1?Q	SH		E	Rocky streamsides, sometimes submerged
Linum sulcatum var. harperi	Harper Grooved Flax	G5T2	SH			Dry pinelands
Listera australis	Southern Twayblade	G4	S2			Poorly drained circumneutral soils
Listera smallii	Appalachian Twayblade	G4	S2			Moist rhododendron thickets
Lithospermum latifolium	Broadleaf Gromwell	G4	S1			Mixed deciduous hardwood forests over limestone
Litsea aestivalis	Pondspice	G3	S2		T	Cypress ponds; swamp margins
Lobelia boykinii	Boykin Lobelia	G2G3	S2S3			Cypress ponds, sometimes with Oxypolis canbyi; Grady ponds; limesink depressions; wet savannas

Lonicera canadensis	American Fly-honeysuckle	G5	SH		Bouldery, cove hardwood forests
Lonicera dioica	Limber Honeysuckle	G5	S1		Mesic, deciduous hardwood forest openings above 3000 ft.
Lophiola aurea	Goldcrest	G4	S1?		Pine flatwoods, bogs
Lotus helleri	Carolina Birdfoot-trefoil	G5T3	S1		Clayey soil over ultramafic rock; post oak-blackjack oak savannas
Ludwigia spathulata	Creeping Smallflower Seedbox	G3G4	S2S3		Exposed shores and bottoms of sinkhole ponds, cypress-gum ponds, bogs; also disjunct on granite outcrop quarry pools
Lycium carolinianum	Carolina Wolfberry	G4	S1		Coastal sand spits
Lycopodium clavatum	Ground Pine	G5	S1		Moist oak forests
Lycopus americanus	American Bugleweed	G5	S1		Wet meadows and old fields along Conasauga River
Lygodium palmatum	Climbing Fern	G4	S2		Acid soils of thickets and open upland forests
Lysimachia fraseri	Fraser's Loosestrife	G2	S1S2	R	Moist, open, bouldery gravel bars and streambanks; edges of sandstone and granite outcrops
Lysimachia loomisii	Loomis Loosestrife	G3	SH		Wet savannas, flatwoods, and margins of Carolina bays (pocosins)
Lysimachia terrestris	Bog Candles	G5	S1		Mountain seeps, wet meadows; streambanks
Lythrum curtissii	Curtiss' Loosestrife	G1	S1	T	Openings in calcareous swamps
Macbridea caroliniana	Carolina Bogmint	G2G3	S1		Bogs; marshes; alluvial woods
Macranthera	Flame Flower	G3	S1?		Wet, sandy

flammea						thickets; pitcherplant bogs
Malaxis spicata	Florida Adders-mouth	G4?	S1			Low hammocks; spring-fed river swamps
Marshallia mohrii	Coosa Barbara Buttons	G3	S2	LT	T	Remnant Coosa Valley prairies; maintained rights-of-way
Marshallia ramosa	Pineland Barbara Buttons	G2	S2		R	Altamaha Grit outcrops; open forests over ultramafic rock
Marshallia trinervia	Broadleaf Barbara's-buttons	G3	S1S2			Streamsides in open, bouldery gravel bars and washed, sandy banks
Matelea alabamensis	Alabama Milkvine	G2	S1		T	Open bluff forests; mesic margins of longleaf pine sandridges
Matelea obliqua	Limerock Milkvine	G4?	S2			Mesic deciduous hardwood forests over limestone
Matelea pubiflora	Trailing Milkvine	G3G4	S2		R	Exposed sandy soils; sandridges
Mecardonia acuminata var. microphylla	Littleleaf Mecardonia	G5T?	S1			Edges of pond margins, sometimes with Lindera melissifolia
Melanthium latifolium	Broadleaf Bunchflower	G5	S2?			Mesic deciduous hardwood forests
Melanthium woodii	Ozark Bunchflower	G5	S2		R	Mesic hardwood forests over basic soils
Menziesia pilosa	Minniebush	G4G5	S1			Rocky ridgetops
Mertensia virginica	Virginia Bluebells	G5	S1S2			Floodplain forests in limestone valleys
Micromeria brownei var. pilosiuscula	Savory	G5T?	S1?			Floodplain forests; muddy banks
Mikania cordifolia	Heartleaf Climbing Hempweed	G5	S1			Bottomland hardwoods and hammocks near coast

Mirabilis albida	Pale Umbrella-wort	G5	S1?		Sandhills of SW Georgia with Warea sessiliflora
Mitreola angustifolia	Narrowleaf Miterwort	G4G5	S1S3		Cypress-gum depressions, wet pine flatwoods
Monotropsis odorata	Sweet Pinesap	G3	S1		Upland forests
Muhlenbergia sobolifera	Sprouting Muhly	G5	S1?		Dry, wooded limestone slopes
Muhlenbergia sylvatica	Woodland Muhly	G5	S1?		Calcareous streambanks
Muhlenbergia torreyana	Torrey Dropseed	G3	SH		Seasonally inundated pond shores, swales and savannas
Myrica inodora	Odorless Bayberry	G4	S2?		Bayheads, titi swamps; forests with pond pine
Myriophyllum laxum	Lax Water-milfoil	G3	S2S3	T	Bluehole spring runs; shallow, sandy, swift-flowing creeks; clear, cool ponds
Najas filifolia	Narrowleaf Naiad	G1	S1		Lakes
Nestronia umbellula	Indian Olive	G4	S2	T	Mixed with dwarf shrubby heaths in oak-hickory-pine woods; often in transition areas between flatwoods and uplands
Neviusia alabamensis	Alabama Snow-wreath	G2	S1	T	Along wet weather streams over limestone
Oldenlandia boscii	Bluets	G5	S3?		Cypress pond margins; exposed pond bottoms in limesinks; sag pond margins; sometimes ditches
Oligoneuron riddellii	Riddell's Goldenrod	G5	S1		Wet, calcareous prairies
Onosmodium molle ssp. occidentale	Marble-seed	G4G5T4?	S1		Limestone glades and adjacent woods
Ophioglossum engelmannii	Limestone Adder-tongue	G5	S2S3		Rocky limestone glades; rarely on

	Fern					granite outcrops (Heggies Rock)
Orbexilum virgatum	Slender Leather-root	G1	SH			Sandridges
Oxalis montana	White Woodsorrel	G5	S1?			Bouldery woods; northern hardwoods
Oxypolis canbyi	Canby's Dropwort	G2	S2	LE	E	Cypress ponds and sloughs; wet savannas
Oxypolis ternata	Savanna Cowbane	G3	S2			Wet pine savannas and bogs
Pachysandra procumbens	Allegheny-spurge	G4G5	S1S2			Mesic hardwood forests over basic soils
Palafoxia integrifolia	Palafoxia	G3G4	S2?			Sandy pine-oak scrub
Palamocladium leskeoides	A Moss	G3G5	S1?			Rock face (dry limestone?), Lookout Mountain
Panax quinquefolius	American Ginseng	G3G4	S3			Mesic hardwood forests; cove hardwood forests
Panax trifolius	Dwarf Ginseng	G5	S1			Mesic hardwood-coniferous forests
Panicum hirstii	Hirst's Panic Grass	G1	SH	C	E	Cypress ponds, wet savannas and sloughs
Panicum neuranthum	Panic Grass	G5?	S1?			Seasonally wet, pine savanna-pondcypress pond ecotone
Panicum tenerum	Panic Grass	G4	S1			Wet pine savannas near the coast
Parietaria pensylvanica	Pennsylvania Pellitory	G5	S1?			Dry, open, calcareous soil
Parnassia grandifolia	Largeleaf Grass-of-parnassus	G3	SH			Seepy limestone and shale ledges
Paronychia argyrocoma	Silverling	G4	S1			Sandstone and granite outcrops
Paronychia patula	Pineland Nailwort	G3G4	S1?			Dry pinelands; sandhills
Paronychia rugelii var. interior	Rugel's Nailwort	G2?T2?Q	S1?			Longleaf pine-turkey oak scrub, mostly Alapaha River drainage

Paronychia rugelii var. rugelii	Rugel's Nailwort	G2?T2?	S2?		Sandy oak barrens and streambanks
Paronychia virginica	Yellow Nailwort	G4	S1		Serpentine outcrops
Pedicularis lanceolata	Swamp Lousewort	G5	S1		Bogs and wet woods
Pediomelum sp. 2	Dixie Mountain Breadroot	G1	S1		Shallow soils over mafic (serpentine) rock, upland longleaf pine-mixed oak savanna and powerline rights-of-way
Pediomelum subacaule	Nashville Breadroot	G4	S2		Limestone glades
Peltandra sagittifolia	Arrow Arum	G3G4	S2?		Swamps; wet hammocks on pristine sphagnum mats
Penstemon calycosus	Long-sepal Beardtongue	G5	SH		Limestone ledges and streambanks
Penstemon dissectus	Grit Beardtongue	G2	S2	R	Altamaha Grit outcrops and adjacent pine savannas; rarely sandridges
Penstemon pallidus	Beardtongue	G5	S1?		Limestone & shale barrens
Penstemon smallii	Small's Beardtongue	G3	S1?		Open woods on rocky slopes and bluffs in circumneutral soil
Pentodon pentandrus	Pentodon	G5?	S1?		Wet meadows; pond edges
Phacelia fimbriata	Fringed Phacelia	G4	S1		Mesic hardwood forests over basic soils
Phacelia purshii	Miami-mist	G5	S1		Mesic hardwood forests over basic soils
Phaseolus polystachios var. sinuatus	Trailing Bean-vine	G4T3?	S2?		Sandhills; dry pinelands and hammocks
Philadelphus pubescens	Hairy Mockorange	G5?	S1		Limestone ledges and rocky banks
Phlebodium aureum	Goldfoot Fern	G5	S1		Exposed calcareous soil;

					also epiphytic on live oak and sabal palmetto (cabbage palm)
Phlox amplifolia	Broadleaf Phlox	G3G5	S1		Mesic hardwood forests over basic soils
Phyla lanceolata	Fog-fruit	G5	S1?		Low woods along streams
Physalis arenicola	Sandhill Groundcherry	G3?	S1S2		Cypress-heads; scrub thickets
Physostegia angustifolia	Narrowleaf Obedient Plant	G4G5	S1?		Calcareous, seasonally wet, grassy openings of Southwest Georgia, sometimes with Lythrum curtissii
Physostegia leptophylla	Tidal Marsh Obedient Plant	G4?	S2S3	T	Freshwater tidal marshes; disjunct in wet savannas of extreme SW Georgia
Piloblephis rigida	Pennyroyal	G3G4	S1		Myrtle oak scrub
Pilularia americana	American Pillwort	G5	S2		Granite outcrops; seasonally exposed muddy shores
Pinguicula primuliflora	Clearwater Butterwort	G3G4	S1	T	In shallow, sandy, clearwater streams and seeps; Atlantic whitecedar swamps
Pityopsis oligantha	Narrow-leaved Golden-aster	G2G4	S1S2		Flatwoods, bogs and seeps of Southwest Georgia
Pityopsis pinifolia	Sandhill Golden-aster	G4	S2	T	Sandhills near fall line
Plagiochila caduciloba	Gorge Leafy Liverwort	G2	S1?		Moist cliff faces
Plagiochila sharpii	Sharp's Leafy Liverwort	G2G4	S1?		Moist cliff faces and spray zones
Plagiochila sullivantii	Sullivant's Leafy Liverwort	G2	SH		Seepy rock cliffs
Plagiomnium carolinianum	Mountain Wavy-leaf Moss	G3	S2?		Moist cliff faces
Plantago sparsiflora	Pineland Plantain	G3	S2		Open, wet pine savannas; shallow

						ditches and seeps, especially in mowed rights-of-way
Platanthera blephariglottis var. blephariglottis	Northern White Fringed Orchis	G4G5T4?	S1?			Bogs and seeps; wet savannas
Platanthera blephariglottis var. conspicua	Southern White Fringed Orchid	G4G5T3T4	S2?			BOGS, SEEPS, ROADSIDES, WET SAVANNAS
Platanthera chapmanii	Chapman's Yellow Fringed Orchid	G4?	SH			OPEN, WET MEADOWS; PINE FLATWOODS
Platanthera flava var. herbiola	Leafy Southern Tubercled Orchid	G4T4Q	S1?			Red maple-gum swamps
Platanthera grandiflora	Large Purple Fringed Orchid	G5	S1			Wet thickets; seepy open northern hardwood forests
Platanthera integra	Yellow Fringeless Orchid	G3	S2			Wet savannas, pitcherplant bogs
Platanthera integrilabia	Monkeyface Orchid	G2G3	S1S2	C	T	Red maple-gum swamps; peaty seeps and streambanks with Parnassia asarifolia and Oxypolis rigidior
Platanthera nivea	Snowy Orchid	G5	S2S3			Wet savannas, pitcherplant bogs
Platanthera peramoena	Purple Fringeless Orchid	G5	S1			Wet meadows, openings among bottomland hardwoods
Platanthera psycodes	Small Purple-fringe Orchid	G5	S1?			Wet thickets; seepy, open, northern hardwood forests
Platyhypnidium pringlei	Pringle's Platyhypnidium	G2G3	S1			Seepy rock cliffs
Polemonium reptans	Jacobs Ladder	G5	S1			Mesic hardwood forests over basic soils
Polygala balduinii	White Milkwort	G4	S1?			Wet pine savannas
Polygala	Georgia	G3G4	S1			Oak-pine scrub

leptostachys	Milkwort			
Polygonum amphibium var. emersum	Water Smartweed	G5T5	S1	MARSHY MARGIN OF FRESHWATER POND WITH LEITNERIA FLORIDANA
Polygonum arifolium	Halberd-leaf Tear-thumb	G5	S1	Marshes and wet thickets
Polygonum glaucum	Sea-beach Knotweed	G3	SH	Coastal beaches in dune depressions and among protected accumulations of beach wrack
Polygonum meisnerianum var. beyrichianum	Meisner's Tear-thumb	G5?T5?	S1?	Shallow water in and along the Aucilla River
Polymnia laevigata	Tennessee Leafcup	G3	S1	Bouldery slopes
Ponthieva racemosa	Shadow-witch Orchid	G4G5	S2?	Calcareous swamps; marly outcrops
Portulaca biloba	Grit Portulaca	G1G2	S1	Altamaha Grit outcrops
Portulaca umbraticola ssp. coronata	Wingpod Purslane	G5T2	S2	Granite outcrops; Altamaha Grit outcrops
Potamogeton amplifolius	Bigleaf Pondweed	G5	S1	Sluggish streams; ponds
Potamogeton pusillus	Pigmy Pondweed	G5	S1?	Shallow creeks and rivers over calcareous bedrock
Prenanthes barbata	Flatwoods Rattlesnake-root	G3	S2	Limestone glades and barrens, edges of remnant prairies
Prunus mexicana	Mexican Plum	G4G5	S1?	Remnant prairies
Prunus pensylvanica	Fire Cherry	G5	S2	Rocky summits, especially following fire
Prunus virginiana	Chokecherry	G5	S1	Boulderfields in northern hardwood forests
Psilotum nudum	Whisk Fern	G5	S1	Epiphytic in hammocks, Okefenokee Swamp; on palm

						trunks in coastal habitats; rarely in lawns and sandy openings
Pteroglossaspis ecristata	Wild Coco	G2	S1			Grassy saw palmetto barrens; longleaf pine grasslands, sometimes with Schwalbea americana
Ptilimnium costatum	Eastern Bishopweed	G3G4	S2?			Remnant wet prairies; bottomland hardwood forests
Ptilimnium nodosum	Harperella	G2	S1	LE	E	Granite outcrop seeps; shallow seasonal ponds in limesink depressions
Ptilimnium sp. 1	Mock Bishop-weed	G1	SH			Tidal freshwater marshes
Pycnanthemum albescens	White-leaved Mountain-mint	G5	S1S2			Open, mesic woods
Pycnanthemum beadlei	Beadle's Mountain-mint	G2G4	S2?			ROCKY OPEN WOODS; EDGES OF ROCK OUTCROPS
Pycnanthemum curvipes	Stone Mountain Mint	G3	S2			Rocky, upland oak-hickory forests
Pycnanthemum virginianum	Virginia Mountain-mint	G5	S1			Wet meadows and barrens
Quercus arkansana	Arkansas Oak	G3	S2S3			Sandy upper ravine slopes
Quercus austrina	Bluff White Oak	G5	S3?			Bluff forests, often in circumneutral soils; floodplain hammocks; edges of Altamaha Grit outcrops
Quercus chapmanii	Chapman Oak	G4G5	S2			Sandridges; dunes; oak-pine scrub
Quercus imbricaria	Shingle Oak	G5	S1			Sandy, moist hardwood flats and headwater slopes
Quercus oglethorpensis	Oglethorpe Oak	G3	S2		T	Broad River bottomlands; upland seepage swamps over

						Iredell and Enon soils with seasonally wet clay beds
Quercus palustris	Pin Oak	G5	SH			Floodplain forests; margins of sag ponds
Quercus prinoides	Dwarf Chinkapin Oak	G5	S2			Upland oak-hickory-pine forests; usually over basic soils
Quercus sinuata	Durand Oak	G5	S1S2			Bluff forests; calcareous slopes near streams
Rhexia aristosa	Awned Meadowbeauty	G3	S2			Pond margins and wet savannas
Rhexia nuttallii	Nuttall Meadowbeauty	G4?	S1?			Pine flatwoods; bogs
Rhexia parviflora	Small-flowered White Meadowbeauty	G2	SH			Limesink pond margins, perhaps in openings under pond-cypress
Rhododendron prunifolium	Plumleaf Azalea	G3	S3		T	Mesic hardwood forests in ravines and on sandy, seepy streambanks
Rhus michauxii	Dwarf Sumac	G2	S1	LE	E	Open forests over ultramafic rock
Rhus typhina	Staghorn Sumac	G5	S1			Open montane forests
Rhynchospora alba	Northern White Beaksedge	G5	S1			Mountain bogs and seeps; disjunct in Okefenokee Swamp, as is cottongrass (Eriophorum)
Rhynchospora crinipes	Bearded Beaksedge	G1	S1			Streambanks and shallow streambeds
Rhynchospora culixa	Georgia Beaksedge	G1Q	S1			Pine savannas; flatwoods
Rhynchospora decurrens	Swamp-forest Beaksedge	G3G4	S1?			Swamps
Rhynchospora harperi	Harper's Beaksedge	G4?	S1S2			Cypress pond margins and wet savannas; limesink depression ponds (dolines)
Rhynchospora	Southern White	G3	S1?			Peaty, sandhill

macra	Beaksedge				seepage slopes; streamhead pocosins
Rhynchospora microcarpa	Southern Beaksedge	G5	S1S2		clay-based Carolina bays; swamps
Rhynchospora oligantha	Feather-bristle Beaksedge	G4	S1?		Bogs; sea-level fens; wet savannas
Rhynchospora pleiantha	Coastal Beaksedge	G2	SH		Margins of limesink depression ponds (dolines)
Rhynchospora punctata	Pineland Beaksedge	G1?	S1?		Wet savannas, pitcherplant bogs
Rhynchospora scirpoides	Long-beak Baldrush	G4	S2?		Floating mats in ponds; pond margins
Rhynchospora solitaria	Autumn Beakrush	G1	S1		Wet, sandy, peaty depressions
Rhynchospora stenophylla	Chapman's Beakrush	G4	S2		Wet, sandy, peaty depressions; Chamaecyparis seeps
Rhynchospora thornei	Thorne's Beakrush	G2	S2		Margins of limesink ponds; moist limestone barrens, wet prairies
Rhynchospora torreyana	Torrey Beakrush	G4	S1?		Bogs; wet savannas
Ribes curvatum	Granite Gooseberry	G4	S2		Rocky upland forests; bouldery mesic slopes
Rudbeckia auriculata	Swamp Black-eyed Susan	G1	S1		Swampy woods
Rudbeckia fulgida var. speciosa	Showy Orange Coneflower	G5T4?	S1?		Limestone barrens; open woods over basic soils
Rudbeckia grandiflora	Largeflower Coneflower	G5	SH		Limestone glades and barrens
Rudbeckia heliopsidis	Little River Black-eyed Susan	G2	S1		Limestone or sandstone barrens and streamsides
Ruellia noctiflora	Night-blooming Wild Petunia	G2	SH		Open, slash pine flatwoods
Sabatia capitata	Cumberland Rose Gentian	G2	S2	R	Meadows over sandstone or shale
Sageretia	Tiny-leaf	G4	S1	T	Calcareous bluff

minutiflora	Buckthorn					forests; maritime forests over shell mounds
Sagittaria platyphylla	Ovate-leaved Arrowhead	G5	S1?			Marshes and shores
Sagittaria secundifolia	Little River Water-plantain	G1	S1	LT	T	Crevices in sandstone in fast flowing streams
Salix floridana	Florida Willow	G2	S1		E	Spring runs; seepy, sphagnous wetlands with Eleocharis tortilis, Itea, Alnus, Orontium, Arnoglossum sulcatum
Sambucus racemosa ssp. pubens	Red Elderberry	G5T4T5	S1			Boulderfields; high elevation summits (e.g.; Hightower Bald, Brasstwon Bald)
Sanguisorba canadensis	Canada Burnet	G5	S1		T	Seepy meadows and thickets
Sanicula trifoliata	Beak-fruit Sanicle	G4	S1?			Mesic hardwood forests
Sapindus saponaria	Soapberry	G5	S1			Shell mound forests
Sarracenia flava	Yellow Flytrap	G5?	S3S4		U	Wet savannas, pitcherplant bogs
Sarracenia leucophylla	Whitetop Pitcherplant	G3	S1		E	Wet savannas, pitcherplant bogs
Sarracenia minor	Hooded Pitcherplant	G4	S4		U	Wet savannas, pitcherplant bogs
Sarracenia oreophila	Green Pitcherplant	G2	S1	LE	E	Wet meadows; upland bogs
Sarracenia psittacina	Parrot Pitcherplant	G4	S2S3		T	Wet savannas, pitcherplant bogs
Sarracenia purpurea	Purple Pitcherplant	G5	S1		E	Swamps, wet rhododendron thickets
Sarracenia rubra	Sweet Pitcherplant	G3	S2	(PS)	E	Atlantic white cedar swamps; wet meadows
Saxifraga careyana	Carey Saxifrage	G3	SH			Moist rock ledges
Saxifraga texana	Texas Saxifrage	G4	S1			Granite outcrops
Schisandra glabra	Bay Starvine	G3	S2		T	Rich woods on stream terraces and

						lower slopes
Schoenocaulon dubium	Florida Feather-shank	G3?	SH			Pine savannas
Schoenolirion elliottii	White Sunnybell	G3	S1?			Wet savannas
Schwalbea americana	Chaffseed	G2	S1	LE	E	Open pinelands, as in well-managed, somewhat moist longleaf pine-wiregrass forests seeps
Scirpus cespitosus	Tufted Club-rush	G5	S1			Seepy ledges
Scirpus cylindricus	Salt-marsh Bulrush	G5	SH			Brackish marshes
Scirpus erismanae	Bulrush	G?Q	S1?			Pond shores in peaty sands
Scirpus etuberculatus	Canby's Club-rush	G3G4	S1S2			Marshes; shallow ponds; peaty swamps, as Okefenokee Swamp and Atlantic whitecedar swamps
Scirpus expansus	Woodland Bulrush	G4	S1S2			Marshes and streambeds
Scirpus hallii	Hall Bulrush	G2	SH			Pond shores in peaty sands
Scutellaria altamaha		G2G3	S1?			Sandy, deciduous woods
Scutellaria arenicola	Sandhill Skullcap	G3G4	SH			Sandy scrub
Scutellaria leonardii	Glade Skullcap	G4Q	S2			Limestone glades
Scutellaria mellichampii	Skullcap	GNRQ	S1?			Sandy deciduous woods
Scutellaria montana	Large-flowered Skullcap	G2	S2	LT	T	Mesic hardwood-shortleaf pine forests; usually mature forest with open understory, sometimes without a pine component
Scutellaria nervosa	Bottomland Skullcap	G5	S1			Floodplain forests
Scutellaria ocmulgee	Ocmulgee Skullcap	G2	S2		T	Mesic hardwood forests; bluff forests

Scutellaria saxatilis	Rock Skullcap	G3	S1		
Scutellaria serrata	Showy Skullcap	G4G5	S1		
Sedum nevii	Nevius' Stonecrop	G3	S1	T	Gneiss ledges on river bluffs
Sedum pusillum	Granite Stonecrop	G3	S3	T	Granite outcrops, often in mats of Hedwigia moss under Juniperus virginiana
Selaginella ludoviciana	Louisiana Spikemoss	G3G4	S1?		Swamp margins; wet meadows
Senecio millefolium	Blue Ridge Golden Ragwort	G2	S1	T	High elevation rock outcrops
Senecio pauperculus	Meadow Golden Ragwort	G5	S1?		Moist meadows and prairies
Shortia galacifolia	Oconee Bells	G2	SE1?	E	Mesic forests with mountain laurel and rhododendron
Sibbaldiopsis tridentata	Three-tooth Cinquefoil	G5	S1	E	Rocky summits
Sida elliottii	Elliott's Fanpetals	G4G5	S2?		Dry or moist openings in sandy woods; limesink pond margins, limestone glades and barrens
Sideroxylon alachuense	Silver Buckthorn	G1	S1?		Sandy hammocks; islands in Okefenokee Swamp; shell middens
Sideroxylon sp. 1	Ohoopee Bumelia	G3Q	S3		Dry longleaf pine woods with oak understory; often hidden in wiregrass
Sideroxylon thornei	Swamp Buckthorn	G2	S2	E	Forested limesink depressions; calcareous swamps
Silene caroliniana	Carolina Pink	G5	S2?		Granite outcrops and sandhills near the Ogeechee and Savannah Rivers
Silene ovata	Mountain Catchfly	G2G3	S1S2		Mesic deciduous or beech-magnolia forests over

						limestone; bouldery, high elevation oak forests
Silene polypetala	Fringed Campion	G2	S2	LE	E	Mesic deciduous forests
Silene regia	Royal Catchfly	G3	S1		R	Limestone barrens; remnant prairies
Silene rotundifolia	Roundleaf Catchfly	G4	S1			Moist sandstone ledges and cliffs, often with Heuchera villosa
Silphium mohrii	Cumberland Rosinweed	G3?Q	S1?			Rocky hardwood forests
Silphium radula	Rosinweed	G4	SH			Rocky hardwood forests
Sium floridanum	Florida Water-parsnip	G1Q	S1?			Calcareous swamps; floodplains
Smilax lasioneuron	Carrion-flower	G5	S2?			Pine-oak-hickory forests; bluff forests
Smilax leptanthera	Catbrier	GHQ	SH			Deciduous forests
Solanum pumilum	Dwarf Horse-nettle	G5T1	SH			Thickets; calcareous barrens
Solidago porteri	Porter Goldenrod	GHQ	SH			Upland forests
Solidago simulans	Cliffside Goldenrod	G1	S1			Seepy summits of granite domes; moist, steep, rocky slopes and cliffs
Solidago speciosa var. rigidiuscula	Goldenrod	G5T4	S1			Limestone barrens
Solidago uliginosa var. uliginosa		G4G5T4T5	S1			
Sorbus americana	American Mountain-ash	G5	S1			Grassy balds; northern hardwood forests
Spartina pectinata	Prairie Cordgrass	G5	SE1?			Relict prairies in calcareous flatwoods
Spermacoce glabra	Smooth Buttonweed	G4G5	S2?			Alluvial woods; margins of sloughs and oxbow lakes
Spermolepis	Rough-fruited	G5	S1			Relict prairies in

inermis	Spermolepis					the Black Belt over marly Oktibbeha soils
Spiraea alba var. latifolia	Broadleaf White Spirea	G5T5	S1			Mountain bogs; roadside seepage slopes
Spiraea tomentosa	Hardhack	G5	S1			Wet meadows
Spiraea virginiana	Virginia Spirea	G2	S1	LT	T	Bouldery gravel bars and ledges along major streams
Spiranthes brevilabris	Downy Slender Ladies-tresses	G2G3	SH			Wet, pine savannas and flatwoods, well-managed by fire
Spiranthes eatonii	Eaton's Ladies-tresses	G2G4	S2?			Cemeteries, roadsides; drier pine flatwoods
Spiranthes floridana	Florida Ladies-tresses	G3G4	S1?			Wet savannas; mowed grassy openings in Okefenokee area
Spiranthes longilabris	Giant Spiral Ladies-tresses	G3	S1			Pine flatwoods, wet savannas, low hammocks with saw palmetto
Spiranthes magnicamporum	Great Plains Ladies-tresses	G4	S1		E	Limestone glades
Spiranthes ovalis var. erostellata	Self-pollinating Oval Ladies-tresses	G5?T4?	S2S3			SEEPY MARGINS OF SMALL STREAMS; FLOODPLAIN WOODS
Spiranthes sylvatica	Pale Green Ladies-tresses	G?	S1?			Live oak hammocks; other open woodlands
Sporobolus heterolepis	Prairie Dropseed	G5	S1			Calcareous glades and barrens
Sporobolus pinetorum	Pineland Dropseed	G3	S2?			Wet savannas with wiregrass
Sporobolus teretifolius	Wire-leaf Dropseed	G2?	S2?			Longleaf pine-wiregrass savannas, pitcherplant bogs
Stachys eplingii	Epling's Hedge-nettle	G5	S1?			Mesic forests, wet meadows, over mafic or calcareous

						soils
Stachys hispida	Hispid Hedge-nettle	G4Q	S2?			Wet meadows, mesic forests, swampy woods, seeps, and boulderfields
Stachys hyssopifolia var. lythroides	Tallahassee Hedge-nettle	G5T1Q	S1			Moist longleaf pine savannas; roadside ditches
Stachys latidens	Broad-toothed Hedge-nettle	G4G5Q	S2?			Cove hardwoods and mesic forests
Stachys nuttallii	Nuttall's Hedge-nettle	G5?	S2			Mesic hardwood forests, mostly calcareous
Stewartia malacodendron	Silky Camellia	G4	S2		R	Along streams on lower slopes of beech-magnolia or beech-basswood-Florida maple forests
Stokesia laevis	Stokes Aster	G4	S1			Pitcherplant bogs
Streptopus roseus	Rosy Twisted Stalk	G5	S1			High elevations boulderfields
Stylisma pickeringii var. pickeringii	Pickering's Morning-glory	G4T2T3	S2		T	Open, dry, oak scrub of sandhills
Stylophorum diphyllum	Celandine Poppy	G5	S1			Mesic hardwood forests over limestone
Symphyotrichum pratense	Silky Aster	G5TNR	S1			Limestone glades
Symphyotrichum sericeum	Silky Aster	G5	S1			Limestone glades
Teloschistes exilis	Orange Fructicose Bark Lichen	G3G5	S1?			Relict Blackland prairies; on bark, especially on stunted Campsis radicans and in Cornus asperifolia thickets
Tephrosia chrysophylla	Sprawling Goats Rue	G4G5	S1			Dry, sandy scrub
Tephrosia mohrii	Dwarf Goats Rue	G3	S1?			Scrub; longleaf pine-wiregrass savannas
Thalia dealbata	Flag	G4	S1			Brackish sloughs and marshes
Thalictrum	Cooley's	G1	S1	LE	E	Pond margins and

cooleyi	Meadowrue				wet savannas
Thalictrum coriaceum	Leatherleaf Meadowrue	G4	S1?		Rich woods
Thalictrum debile	Trailing Meadowrue	G2	S1	T	Mesic hardwood forests over limestone
Thalictrum subrotundum	Roundleaf Meadowrue	G1G2Q	SH		Swamp edges, streamsides; mesic ravine forests
Thaspium chapmanii	Creamy Meadow-parsnip	G?	S3?		Hardwood forests and glades, near edges of gumbo flats and rocky outcrops of limestone or amphibolite
Thaspium pinnatifidum	Cutleaf Meadow-parsnip	G2G3	S1		Limestone outcrops and barrens
Thelypteris ovata	Ovate Maiden Fern	G3G5	S2S3		Calcareous hammocks; limesinks; mesic hardwood forests
Thermopsis fraxinifolia	Ash-leaf Bush-pea	G3?Q	S2?		Oak and oak-pine ridge forests
Thermopsis mollis	Downy Bush-pea	G3G4	S1?		Dry slopes and ridges; mostly in open pine-oak forests
Thermopsis villosa	Aaron's Rod	G3?	S1?		Mesic forests, floodplains and roadsides; mostly in sandy soils .
Tillandsia bartramii	Bartram's Air-plant	G4	S2		Epiphytic in bay swamps, freshwater tidal swamps; beech-magnolia bluff forests
Tillandsia fasciculata	Quill-leaf Air-plant	G5	S1		Epiphytic on evergreen oaks
Tillandsia recurvata	Ball-moss	G5	S1	T	Epiphytic in live oak maritime forests
Tillandsia setacea	Pine-needle Air-plant	G5	S1?		Epiphytic in bluff forests on evergreen hardwoods
Tofieldia	Sticky False	G5	SH		Open peaty

glutinosa	Asphodel					swamps
Torreya taxifolia	Florida Torreya	G1	S1	LE	E	Rich ravines in extreme Southwest Georgia
Tradescantia roseolens	Rosy Spiderwort	G5	S2?			Dry, sandy woods
Tragia cordata	Heartleaf Nettle Vine	G4	S2?			Dry, usually rocky, calcareous woods; also relict prairie openings on the Fort Valley Plateau
Trepocarpus aethusae	Trepocarpus	G4G5	S2?			Floodplain forests
Triadenum tubulosum	Broadleaf Marsh St. Johnswort	G4?	S1S3			Swamps
Trichomanes boschianum	Appalachian Filmy Fern	G4	S1			Acidic ledges and overhangs
Trichomanes petersii	Dwarf Filmy Fern	G4G5	S2			Acidic boulders, ledges and overhangs; Altamaha Grit outcrops
Tridens carolinianus	Carolina Redtop	G3	S1?			Dry, open mixed oak-pine forests of the Fall Line Sandhills
Trientalis borealis	Northern Starflower	G5	S1S2		E	Rocky, northern hardwood forests
Trillium discolor	Pale Yellow Trillium	G2	S1S2			Mesic hardwood forests only in Savannah River watershed
Trillium flexipes	Bent Trillium	G5	S1			Mesic hardwood forests over limestone
Trillium lancifolium	Lanceleaf Trillium	G3	S3			Floodplain forests; also lower rocky slopes over basic soils
Trillium persistens	Persistent Trillium	G1	S1	LE	E	Mesic hardwood forests, upland forests
Trillium pusillum	Least Trillium	G3	S1			Red maple-blackgum swampy woods in sticky clay soils
Trillium reliquum	Relict Trillium	G2	S2	LE	E	Mesic hardwood

				forests; limesink forests; usually with Fagus and Tilia
Trillium simile	Sweet White Trillium	G3	S2	Cove hardwoods, sometimes with Rhododendron maximum
Trillium sulcatum	Barksdale Trillium	G4	S2	Mesic hardwood forests
Triosteum angustifolium	Narrowleaf Wild Coffee	G5	S1?	Mesic hardwood forests over limestone
Triosteum aurantiacum	Wild Coffee	G5	S2?	Open woodlands over circumneutral or calcareous soils
Triphora trianthophora	Three-birds Orchid	G3G4	S2?	Loamy soils of rhododendron thickets; hardwood forests
Tsuga caroliniana	Carolina Hemlock	G3	S1	Rocky bluffs
Ulmus serotina	September Elm	G4	S1	Mesic hardwood forests over limestone
Utricularia olivacea	Leafless Dwarf Bladderwort	G4	S1?	Shallow ponds, especially limesink ponds or dolines of Southwest Georgia
Utricularia resupinata	Lavender Bladderwort	G4	S1?	Pools in pine flatwoods of Southwest Georgia; also disjunct in Northeast Georgia mountain swamps
Vaccinium crassifolium	Evergreen Lowbush Blueberry	G4G5	SH	Open margins of Carolina bays
Vaccinium erythrocarpum	Bearberry	G5	S1	Mixed oak-heath forests
Veratrum viride	American False Hellebore	G5	S2	Seepy northern hardwood forests
Verbesina helianthoides	Hairy Wingstem	G5	SH	Prairies; dry woods
Verbesina walteri	Carolina Crownbeard	G3?	S1?	Moist slopes of hardwood bluffs and edges of colluvial swamps

					with calcareous substrate; along Savannah River
Viburnum bracteatum	Limerock Arrow-wood	G1	S1	E	Mesic hardwood forests over limestone
Viburnum carolinianum	Carolina Arrow-wood	G4G5Q	S1		Mountain bogs and openings in red maple-blackgum swamps
Viburnum lantanoides	Witch-hobble	G5	SH		Northern hardwood forests
Viburnum rafinesquianum var. affine	Limerock Downy Arrowwood	G5T?	S1		Limestone bluffs along major rivers
Viburnum rafinesquianum var. rafinesquianum	Downy Arrowwood	G5T4T5	S1?		Rocky woods and bluffs; both granite and limestone
Vigna luteola	Wild Yellow Cowpea	G5	S2?		Open swamps; maritime beaches and tidal flats
Viola egglestonii	Glade Violet	G4	S2		Limestone glades
Vitis palmata	Catbird Grape	G4	SH		Floodplain forests; river banks
Vitis rotundifolia var. munsoniana	Munson Grape	G5T4?	S1		Floodplain forests; blackwater streamsides
Vittaria lineata	Shoestring Fern (sporophyte)	G4	S1		Altamaha Grit outcrops; epiphytic on cabbage palms; rocky slopes
Waldsteinia lobata	Piedmont Barren Strawberry	G2	S2	T	Stream terraces and adjacent gneiss outcrops
Warea sessilifolia	Sandhill-cress	G2G4	S1		Sandhills scrub
Websteria confervoides	Algal Bulrush	G3G5	S1?		Lakes and ponds
Woodsia scopulina ssp. appalachiana	Appalachian Cliff Fern	G5T4	S1		Sandstone and shale cliffs
Xerophyllum asphodeloides	Eastern Turkeybeard	G4	S1	R	Xeric oak-pine forests
Xyris chapmanii	Chapman Yellow-eyed Grass	G3	S1?		Streamhead seepage bogs in deep muck with numerous other

						xyrids and graminoids
Xyris drummondii	Drummond Yellow-eyed Grass	G3	S1			Pine flatwoods
Xyris scabrifolia	Harper Yellow-eyed Grass	G3	S1			Sedge bogs; pitcherplant bogs; pine flatwoods
Xyris tennesseensis	Tennessee Yellow-eyed Grass	G2	S1	LE	E	Seepy margins of limestone spring runs
Zamia integrifolia	Florida Coontie	G3G4Q	SH			Maritime live oak forests
Zanthoxylum americanum	Northern Prickly-ash	G5	S1?			Rocky, openly wooded slopes; river banks and terraces
Zenobia pulverulenta	Zenobia	G4?	S1			Cypress gum pond margins and sandhill depressions
Zephyranthes simpsonii	Simpson Rain Lily	G2G3	S1			Pine flatwoods; edges of sloughs on southcentral coastal plain
Zigadenus leimanthoides	Death-camus	G4Q	S1			Sandhill bogs; pine flatwoods

NOTE: This is a working list and is constantly revised (see element occurance data disclaimer). For the latest changes, acknowledgment of numerous sources, interpretation of data, or other information connected with this list, please contact:

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Special Concern Plant Species in Georgia

Find details for the listed plants on NatureServe.

Date of information - 10/22/2004
660 plants on this list

Scientific Name	Common Name	Global Rank (what's this?)	State Rank (what's this?)	Federal Status (what's this?)	State Status (what's this?)	Habitat in Georgia
Acacia farnesiana	Sweet Acacia	G5	SE1?			Sandy flats behind dunes; open live oak woods
Acer spicatum	Mountain Maple	G5	S2			High elevation boulder fields
Acorus americanus	Sweetflag	G5	S1S2			Okefenokee Swamp (?); seepy creekside with Xyris tenesseensis in Bartow Co.
Aeschynomene viscidula	Sticky Joint-vetch	G5?	S1?			Sandy pinelands; saltmarsh edges
Aesculus glabra	Ohio Buckeye	G5	S2			Mesic forests in circumneutral soil
Aesculus parviflora	Bottlebrush Buckeye	G2G3	S2S3			Mesic bluff and ravine forests
Agalinis aphylla	Scale-leaf Purple Foxglove	G3G4	S3?			Longleaf pine-wiregrass savannas; pine flatwoods
Agalinis decemloba	Purple Foxglove	G4Q	S1?			Dry, open woods over clays and sands
Agalinis divaricata	Pineland Purple Foxglove	G3?	S1?			Dry, grassy, pine-scrub oak ridges; extreme SW Georgia
Agalinis filicaulis	Spindly Purple Foxglove	G3G4	S2?			Seasonally wet, longleaf pine-wiregrass savannas; grassy pine barrens
Agalinis filifolia	Seminole Purple Foxglove	G4?	S1S2			Dry, sandy, longleaf pinelands
Agalinis tenuifolia var. leucanthera	Slender Purple Foxglove (white-flowered)	G5T?	SH			Savannas; open woodlands
Agarista populifolia	Pipe-stem Fetterbush	G4G5	SH			Swamps; hydric hammocks; marly spring runs
Agastache	Yellow Giant	G5	SH			Openings in rich

nepetoides	Hyssop					hardwoods
Agastache scrophulariifolia	Purple Giant Hyssop	G4	SH			Forested floodplains; river terraces
Agrimonia gryposepala	Hooked Harvest-lice	G5	S1?			Rich, circumneutral woodlands
Allium speculae	Flatrock Onion	G2	S2		T	Granite outcrops (limited to Lithonia Gneiss types)
Alnus maritima	Seaside Alder	G3	S1			Ridge and Valley spring runs in standing water
Amelanchier sanguinea	Roundleaf Serviceberry	G5	S1?			Rocky slopes
Amorpha georgiana var. georgiana	Georgia Indigo-bush	G3T2	S1			River terraces; floodplain woods; Flint Kaolin outcrops; mesic habitats with wiregrass,longleaf pine, mixed oaks
Amorpha herbacea var. floridana	Florida Leadbush	G4T?Q	S1			River terraces along the Alapaha River
Amorpha nitens	Shining Indigo-bush	G3?	S1?			Rocky, wooded slopes; alluvial woods
Amorpha schwerinii	Schwerin Indigo-bush	G3G4	S2			Rocky upland woods
Amphianthus pusillus	Pool Sprite	G2	S2	LT	T	Vernal pools on granite outcrops
Amsonia ludoviciana	Louisiana Blue Star	G3	S2			Open woods near granite outcrops (limited to Lithonia Gneiss types)
Andropogon brachystachyus	Shortspike Bluestem	G4	S1?			Wet flatwoods, pond margins and bogs
Andropogon longiberbis	Long-beard Bluestem	G5	S2?			Dry sandhills
Andropogon mohrii	Bog Bluestem	G4?	S2?			Longleaf pine-wiregrass savannas; pine-cypress savannas
Anemone berlandieri	Glade Windflower	G4?	S1S2			Granite outcrop ecotones; openings over basic rock

Anemone caroliniana	Carolina Windflower	G5	S1?			Upland seepage swamp openings over Iredell soils; wet meadows
Angelica dentata	Sandhill Angelica	G2G3	S2?			Longleaf pine-wiregrass savannas
Arabis georgiana	Georgia Rockcress	G1	S1	C	T	Rocky or sandy river bluffs and banks, in circumneutral soil
Arabis lyrata	Lyre-leaf Rockcress	G5	SH			Shaded rock bluffs
Arabis missouriensis	Missouri Rockcress	G5?Q	S2			Granite and amphibolite outcrops
Arabis patens	Spreading Rockcress	G3	SH			Wooded limestone slopes
Aralia nudicaulis	Wild Sarsaparilla	G5	S2?			Northern hardwood forests
Aristida gyrans	Corkscrew Three-awn Grass	G4G5	S1?			Dry sandy pinelands
Aristida simpliciflora	Chapman Three-awn Grass	G3G4	SH			Longleaf pine-wiregrass savannas
Armoracia lacustris	Lake-cress	G4?	S1?			Shallow water of swamps and lake margins
Arnoglossum diversifolium	Variable-leaf Indian-plantain	G2	S2		T	Calcareous swamps
Arnoglossum sulcatum	Grooved-stem Indian-plantain	G2G3	S1			Bottomland forests
Asclepias hirtella	Barrens Milkweed	G5	S2			Limestone glades; remnant prairies and nearby roadbanks
Asclepias pedicellata	Savanna Milkweed	G4	S2?			Longleaf pine flatwoods; sandy pinelands with longleaf pine-saw palmetto-myrtle oak (Sapelo Island)
Asclepias purpurascens	Purple Milkweed	G5?	S1			Calcareous flatwoods, wet meadows near Rome
Asclepias rubra	Red Milkweed	G4G5	SH			Bogs, wet savannas
Asimina pygmaea	Dwarf Pawpaw	G4	S1?			Flatwoods, wet

						savannas
Asimina reticulata	Netleaf Pawpaw	G4	S1			Flatwoods, wet savannas
Asplenium heterochroum	Varicolor Spleenwort	G3G5	SR			Limestone outcrops; marl
Asplenium heteroresiliens	Wagner's Spleenwort	G2Q	S1		T	Limestone and marl outcrops; tabby ruins
Asplenium ruta-muraria	Wall Rue Spleenwort	G5	S1			Limestone outcrops
Aster avitus	Alexander Rock Aster	G3	S3			Granite outcrops in seepy margins with Solidago gracillima and Spiranthes cernua
Aster ericoides	Heath Aster	G5	S1			Limestone glades
Aster eryngiifolius	Snakeroot-leaf Aster	G3G4	S1			Moist pinelands
Aster georgianus	Georgia Aster	G2G3	S2	C		Upland oak-hickory-pine forests and openings; sometimes with Echinacea laevigata or over amphibolite
Aster laevis var. laevis	Smooth Aster	G5T5	S2?			Mesic hardwood forests in circumneutral soil
Aster novae-angliae	New England Aster	G5	S1			Remnant prairies
Aster phlogifolius	Phlox-leaved Aster	G5T5	S1			Mesic hardwood forests over basic soil
Aster praealtus	Willow-leaf Aster	G5	S1?			Lowland forests over limestone
Astragalus canadensis	Canada Milkvetch	G5	S1			Hardwood forests over limestone
Astragalus michauxii	Sandhill Milkvetch	G3	S2			Longleaf pine-wiregrass savannas; turkey oak scrub
Astranthium integrifolium	Wild Daisy	G5	S1?			Limestone glades
Astrolepis sinuata ssp. sinuata	Wavy Cloak Fern	G5?T5?	SE1?			Granite outcrops and boulders
Aureolaria	Spreading	G3	S1			Circumneutral

patula	Yellow Foxglove					alluvial bottoms
Balduina atropurpurea	Purple Honeycomb Head	G2	S2		R	Wet savannas, pitcherplant bogs
Baptisia arachnifera	Hairy Rattleweed	G1	S1	LE	E	Pine flatwoods
Baptisia australis var. aberrans	Glade Blue Indigo	G5T2T3	S2			Limestone glades and barrens
Baptisia australis var. australis	Streamside Blue Indigo	G5T?	S1			Gravel bars
Baptisia lecontei	Leconte Wild Indigo	G4?	S1			Pineland scrub
Baptisia megacarpa	Bigpod Wild Indigo	G2	S1			Floodplain forests
Berberis canadensis	American Barberry	G3	S1			Cherty, thinly wooded slopes
Boltonia caroliniana	Carolina Boltonia	G4?	S1?			Moist lowlands, including wet prairies and flatwoods around Rome
Bouteloua curtipendula	Side-oats Grama	G5	S2			Limestone glades and barrens
Brachyelytrum septentrionale	Northern Shorthusk Grass	G4G5	S1			Rich, north-facing cove forests; moist, north-facing cliff ledges
Brachymenium systylium	Mexican Brachymenium	G5	S1?			Sandstone bluffs.
Brickellia cordifolia	Flyr's Nemesis	G2G3	S1			Mesic hardwood forests
Buchnera americana	Bluehearts	G5?	S1			Wet meadows; seasonally moist barrens and limestone glades
Calamagrostis porteri	Porter's Reedgrass	G4	S1			Base of north-facing, granitic cliffs
Calamintha ashei	Ohoopee Dunes Wild Basil	G3	S2		T	Ohoopee dunes
Callirhoe digitata	Finger Poppy-mallow	G4	SE1?			Open woods and relict prairies; enhanced locally along mowed rights-of-way over calcareous substrates of NW

					Georgia
Callirhoe papaver	Woods Poppy-mallow	G5	S2S3		Openings in oak-pine forests
Callirhoe triangulata	Clustered Poppy-mallow	G3	S2		Sandy scrub
Calopogon multiflorus	Many-flowered Grass-pink	G2G3	SH		Wet savannas; pitcherplant bogs
Calycanthus brockiana	Brock Sweetshrub	G1?Q	SU		Mesic hardwood forests
Calystegia catesbeiana ssp. catesbeiana	Catesby Bindweed	G3T2?Q	S1?		Longleaf pine-wiregrass savannas
Calystegia catesbeiana ssp. sericata	Silky Bindweed	G3T2T3Q	S2S3		Openings in montane oak-hickory-pine forests
Camassia scilloides	Wild Hyacinth	G4G5	S2		Floodplain and mesic hardwood forests over limestone
Campanula aparinoides	Marsh Bellflower	G5	S1?		Mountain bogs and wet meadows, sometimes with Polygonum sagittatum
Campylopus carolinae	Sandhill Awned Moss	G1G2	S2?		Fall line sandhills; Altamaha Grit outcrops in partial shade of mesic oak forests
Cardamine dissecta	Divided Toothwort (blue Ridge Populations)	G4?	S3		Rich, cove forests
Carex aestivaliformis	Sedge	G?Q	S1?		Upland submesic oak forests in Blue Ridge
Carex albursina	White Bear Lake Sedge	G5	S1		Rich, calcareous woods
Carex appalachica	Appalachian Sedge	G4	S1?		Dry to moist, rocky, open woods and heath balds
Carex baltzellii	Baltzell's Sedge	G3	S1	E	Beech-magnolia slope forests
Carex biltmoreana	Biltmore Sedge	G3	S1	T	High elevation ledges and rock faces
Carex	Sedge	G5	SH		High elevation

brunnescens					ledges and grass balds
Carex buxbaumii	Brown Bog Sedge	G5	SH		Sag ponds, peat bogs
Carex careyana	Carey Sedge	G4G5	S1		Mesic hardwood forests over limestone
Carex collinsii	Narrow-fruit Swamp Sedge	G4	S2		Seepage bogs; Atlantic whitecedar swamps; other habitats?
Carex dasycarpa	Velvet Sedge	G4?	S3	R	Evergreen hammocks; mesic hardwood forests
Carex decomposita	Cypress-knee Sedge	G3	S2?		Swamps and lake margins on floating logs
Carex eburnea	Black-seed Sedge	G5	S1		Limestone outcrops and ledges
Carex fissa var. aristata	Sedge	G3G4QT3T4	S1		Wet savannas
Carex floridana	Florida Sedge	G5?	S3		Sandy oak-hickory woods
Carex folliculata	Sedge	G4G5	S1		Mountain bogs
Carex grayi	Asa Gray Sedge	G4	S2S3		Calcareous meadows and alluvial woods
Carex hystericina	Porcupine Sedge	G5	S2?		Spring runs; wet meadows
Carex lucorum	Southern Fibrous Root Sedge	G4	S1?		Wet ledges in Tallulah Gorge
Carex manhartii	Manhart's Sedge	G3	S2S3	T	Cove hardwood forests; other mesic deciduous forests
Carex misera	Wretched Sedge	G3	S1	T	Grassy balds
Carex oligocarpa	Few-fruit Sedge	G4	S2?		Rich hardwood forests over limestone
Carex pedunculata	Longstalk Sedge	G5	S1?		Cove hardwood forests
Carex platyphylla	Broadleaf Sedge	G5	S1		Mesic hardwood forests over basic rock
Carex	Purple Sedge	G4?	S2	T	Mesic hardwood

purpurifera				forests over limestone
Carex radfordii	Radford Sedge	G2	S1?	Rich woods of marble ravines
Carex reniformis	Reniform Sedge	G4?	S1?	Cypress swamps, wet woods and sloughs
Carex roanensis	Roan Mountain Sedge	G2	S1	Boulderfields and exposed granite ledges
Carex rosea	Rosy Sedge	G5	S2?	Dryish hardwood forests
Carex scabrata	Sedge	G5	S2	High elevation boulderfields
Carex scoparia	Broom Sedge	G5	S1?	Bogs and marshes; seepy ledges
Carex seorsa	Weak Stellate Sedge	G4	S1?	Water tupelo swamps
Carex socialis	Social Sedge	G4	S1?	Alluvial floodplain woods, often with Carex intumescens
Carex stricta	Tussock Sedge	G5	S1	Sag ponds and other seasonal depression ponds
Carex torta	Twisted Sedge	G5	S1?	Rocky streambeds
Carex venusta var. minor	Sedge	G4T4	S2?	Floodplains and bottomlands, often with Peltandra virginica
Carex venusta var. venusta	A Sedge	G4T4?	S1?	Peat bogs; wet, mossy woods
Carex woodii	Sedge	G4	S1?	High elevation rock outcrops
Carphephorus bellidifolius	Sandy-woods Chaffhead	G4	S1?	Sandy scrub
Carphephorus pseudoliatris	Lavender Lady	G4G5	SH	Pine flatwoods
Carya laciniosa	Shellbark Hickory	G5	S2?	Bottomland forests
Carya myristiciformis	Nutmeg Hickory	G4	S1	Calcareous flatwoods
Castilleja coccinea	Scarlet Indian-paintbrush	G5	S2?	Open, rocky, chestnut oak woods
Cayaponia quinqueloba	Cayaponia	G4	S1	Swamp forests; sandy openings in floodplains and on riverbanks

Celastrus scandens	Bittersweet	G5	S2?			Open, rocky areas in thickets and deciduous forests
Cephaloziella obtusilobula	Roundleaf Leafy Liverwort	GHQ	SH			Moist cliff faces
Ceratiola ericoides	Rosemary	G4	S2		T	Ohoopee Dunes; deep sandridges
Chaerophyllum procumbens	Spreading Chervil	G5	S2			Low rich woods in circumneutral soil
Chamaecrista deeringiana	Florida Senna	G1G2	S1?			Sandhill scrub; longleaf pine-wiregrass savannas
Chamaecyparis thyoides	Atlantic White-cedar	G4	S2		R	Clearwater stream swamps in fall line sandhills
Cheilanthes alabamensis	Alabama Lipfern	G4G5	S2			Limestone ledges
Chelone cuthbertii	Cuthbert Turtlehead	G3	S1			Bogs and wet meadows
Chrysosplenium americanum	Golden Saxifrage	G5	S1			Pools in rocky montane streams
Cirsium carolinianum	Carolina Thistle	G5	S3			Prairies; open mixed pine-oak woods, shortleaf pine-blackjack oak savannas over serpentine
Cirsium lecontei	Leconte Thistle	G2G3	S1S3			Moist pinelands and savannas
Cirsium muticum	Swamp Thistle	G5	S1?			Remnant wet prairies
Cirsium virginianum	Virginia Thistle	G3	S2?			Moist pinelands; moist longleaf pine/wiregrass savannas
Cleistes bifaria	Spreading Pogonia	G4?	S1?			Mountain seeps and wet meadows
Clematis fremontii	Fremont's Virgin's-bower	G5				
Clematis ochroleuca	Curly-heads	G4	S2			Dry woods in circumneutral soil
Clematis socialis	Alabama Leather Flower	G1	S1	LE	E	Grassy openings in flatwoods of mostly lowland oaks and red maple
Clintonia borealis	Yellow Bead-lily	G5	SH			Northern hardwood forests

Comptonia peregrina	Sweet-fern	G5	S1		Disturbed areas and open upland forests
Corallorhiza maculata	Spotted Coralroot	G5	SH		High elevation hardwood forests; beech gaps
Coreopsis integrifolia	Tickseed	G1G2	S1S2		Floodplain forests, streambanks
Coreopsis latifolia	Broadleaf Tickseed	G3	S1		Mature deciduous forests with open understory
Cornus drummondii	Rough-leaved Dogwood	G5	S1?		Open woods and cedar glades over calcareous shale and limestone
Corydalis flavula	Yellow Corydalis	G5	S1?		Rocky floodplain forests; hardwood ravines over amphibolite or limestone
Corydalis sempervirens	Pale Corydalis	G4G5	S1		Montane ledges and rocky summits
Cotinus obovatus	American Smoketree	G4	S1		Mixed oak-redcedar forests on rocky limestone slopes
Crataegus brachyacantha	Blueberry Hawthorn	G4	SH		Open pinelands
Crataegus pulcherrima	Beautiful Haw	G2G4	S1?		Rich, open deciduous woods and edges
Crataegus triflora	Three-flower Hawthorn	G2	S1		Hardwood forests on rocky, limestone slopes
Croomia pauciflora	Croomia	G3	S1	T	Mesic hardwood forests, usually with Fagus and Tilia
Croton elliottii	Elliott Croton	G2G3	S2S3		Pond margins and wet savannas
Ctenium floridanum	Florida Orange-grass	G2	S1		Moist pine barrens
Cuscuta harperi	Harper's Dodder	G2	S1	T	Altamaha Grit outcrops; granite outcrops; often with Liatris microcephala as host

Cuscuta rostrata	Beaked Dodder	G4	SH		High elevation hardwood forests
Cymophyllus fraserianus	Fraser's Sedge	G4	S1	T	Mixed hardwood-hemlock forests
Cyperus flavicomus	Whiteedge Flatsedge	G5	SE1?		Moist to wet ditches; marshes
Cyperus lupulinus ssp. macilentus	Meagre Hop Flatsedge	G5T5?	S1?		Dry, open pinelands?
Cyperus thyrsiflorus	Thyrsoid Flatsedge	G5	S1?		Wet streambanks and swamps
Cypripedium acaule	Pink Ladyslipper	G5	S4	U	Upland oak-hickory-pine forests; piney woods
Cypripedium kentuckiense	Kentucky Ladyslipper	G3	S1		Forested, springhead seeps in sandy soils
Cypripedium parviflorum var. parviflorum	Small-flowered Yellow Ladyslipper	G5T3T4	S3?	U	Upland oak-hickory-pine forests; mixed hardwood forests
Cypripedium parviflorum var. pubescens	Large-flowered Yellow Ladyslipper	G5T5	S3	U	Upland oak-hickory-pine forests; mixed hardwood forests
Cystopteris tennesseensis	Tennessee Fragile Fern	G5	S1		Seepy limestone-shale outcrops
Dalea candida	Prairie Clover	G5	S1		Limestone glades and barrens
Dalea carnea var. carnea	Pink-tassels	G5T3T4	S1?		Dry, sandy pinelands
Dalea carnea var. gracilis	Sprawling White-tassels	G5T3T4	SH		Wet pine savannas, Southwest Georgia
Dalea feayi	Feay Pink-tassels	G4G5	S1		Dry pinelands and scrub
Dalea gattingeri	Gattinger Prairie Clover	G3G4	S2S3		Limestone glades and barrens
Danthonia epilis	Bog Oat-grass	G3G4	S1?		Mountain bogs
Dasistoma macrophylla	Mullein Foxglove	G4	S1?		Rocky limestone woods
Delphinium carolinianum ssp. calciphilum	Glade Larkspur	G5T2T4	S2		Limestone glades
Delphinium tricorne	Dwarf Larkspur	G5	S2?		Mesic hardwood forests in calcareous areas

Desmodium ochroleucum	Creamflower Tick-trefoil	G1G2	S1			Open, calcareous woodlands, including lower slope of Pigeon Mountain
Desmodium sessilifolium	Sessile-leaf Tick-trefoil	G5	S1?			Sandhills in oak forest openings; perhaps prairie relict areas?
Diarrhena americana	American Dropseed	G4?	S1			Mesic hardwoods over limestone
Dicentra canadensis	Squirrel-corn	G5	S1?			Mesic hardwood forests
Dicentra eximia	Bleeding Heart	G4	S1			Montane ledges and rocky slopes
Dicerandra radfordiana	Radford Dicerandra	G1Q	S1			Sandridges
Diervilla lonicera	Northern Bush-honeysuckle	G5	S1?			Rocky bluffs
Diphasiastrum tristachyum	Ground Cedar	G5	S1			Rocky ledges; upland forests
Draba aprica	Open-ground Whitlow-grass	G3	S1S2		E	Granite and amphibolite outcrops, usually in redcedar litter
Drosera rotundifolia	Roundleaf Sundew	G5	S1?			Seepy montane ledges and sphagnum bogs
Drosera tracyi	Tracy's Dew-threads	G3G4	S1			Pitcherplant bogs; grassy seepage slopes
Dryopteris carthusiana	Spinulose Shield Fern	G5	S1			Strongly sloping, high altitude granitic outcrop
Dryopteris celsa	Log Fern	G4	S2			Floodplain forests; lower slopes of rocky woods
Dryopteris cristata	Crested Wood Fern	G5	SE1?			Swamps
Echinacea laevigata	Smooth Purple Coneflower	G2	S2	LE	E	Upland forests over amphibolite
Echinacea pallida	Pale Purple Coneflower	G4	SE1?			Prairies; perhaps longleaf pine/wiregrass savannas
Echinacea purpurea	Purple Coneflower	G4	S2?			Prairies and glades, circumneutral soils
Echinacea	Prairie Purple	G3	S2S3			Remnant prairies in

simulata	Coneflower				the Coosa flatwoods near Rome
Echinodorus parvulus	Dwarf Burhead	G3Q	S1?		Shallow pools; limesink depression ponds
Elatine triandra	Longstem Waterwort	G5	SE1?		Old quarry pools on granite outcrops
Eleocharis albida	White Spikerush	G4G5	S2S3		Brackish pools
Eleocharis atropurpurea	Spikerush	G4G5	S1S3		Limesink pond margins
Eleocharis compressa	Spikerush	G4	S2S3		Limestone glades and barrens
Eleocharis erythropoda	Spikerush	G5	S1?		Sag pond margins
Eleocharis fallax	Spikerush	G4G5	S1?		Brackish marsh
Eleocharis montana	Nodose Spikerush	G5	SH		Marshy shores and peaty depressions on heavy clay soils
Eleocharis montevidensis	Spikerush	G5	S1		Wet sands on barrier islands; maritime wet grasslands
Eleocharis tenuis var. verrucosa	Warty Slender Spikerush	G5T3T5	S2?		Muddy banks of small streams in Coosa Flatwoods
Eleocharis wolfii	Spikerush	G3?	S1		Shallow pools on granite outcrops
Elliottia racemosa	Georgia Plume	G2G3	S2S3	T	Scrub forests; Altamaha Grit outcrops; open forests over ultramafic rock
Elyonurus tripsacoides	Pan-american Balsamscale	G5?	SH		Pine savannas
Epidendrum conopseum	Green-fly Orchid	G4	S3	U	Epiphytic on limbs of evergreen hardwoods; also in crevices of Altamaha Grit outcrops
Erigenia bulbosa	Harbinger-of-spring	G5	S1		Mesic hardwood forests over basic soils
Erigeron strigosus var. calcicola	Cedar Glade Daisy Fleabane	G5T3	S1		LIMESTONE GLADES OR CEDAR GLADES

Eriocaulon koernickianum	Dwarf Pipewort	G2	S1		Granite outcrops
Eriocaulon texense	Texas Pipewort	G4	S2?		Altamaha grit outcrops; wet pine savannas
Eriochloa michauxii var. michauxii	Michaux's Cupgrass	G3G4T3T4	S2?		Coastal freshwater and brackish marshes; flatwoods
Eriophorum virginicum	Tawny Cotton-grass	G5	S1		Mountain bogs; peaty wet meadows in alluvial flats in Fall Line sandills; also in Okefenokee Swamp
Eupatorium godfreyanum	Godfrey's Eupatorium	G4	S1?		Upland, open woods in circumneutral soils
Eustachys floridana	Florida Finger Grass	G2?	S1?		Sandhills and flatwoods
Evolvulus sericeus var. sericeus	Creeping Morning-glory	G5T3T5	S1	E	Altamaha Grit outcrops; open calcareous uplands
Fimbristylis brevivaginata	Flatrock Fimbry	G2	S2		Granite outcrops
Fimbristylis perpusilla	Harper's Fimbry	G2	S1	E	Exposed muddy margins of pineland ponds
Forestiera godfreyi	Godfrey Privet	G2	S1		Mesic, maritime forests over shell mounds
Forestiera segregata	Florida Privet	G4	S2		Shell mounds on barrier islands in scrub or maritime forests
Fothergilla gardenii	Dwarf Witch-alder	G3G4	S2	T	Openings in low woods; swamps
Fothergilla major	Mountain Witch-alder	G3	S1		Rocky (sandstone, granite) woods; bouldery stream margins
Franklinia alatamaha	Franklin Tree	GXC	SX		Sandridges
Fraxinus quadrangulata	Blue Ash	G5	S1S2		Mesic hardwood forests over limestone
Frullania appalachiana	A Liverwort	G1?	S1		On tree trunks and decaying wood above 3800 ft.

Fuirena longa	Umbrella Sedge	G3G4	SE1?			Pond margins near the coast; perhaps introduced when planting maidencane (Panicum hemitomon) plugs
Fuirena scirpoidea	Southern Umbrella-sedge	G5	S1?			Pineland depressions, wet savannas with Toxicodendron vernix; often in maintained rights-of-way
Galactia floridana	Florida Milk-pea	G3G4	S1?			Pine flatwoods
Gentianopsis crinita	Fringed Gentian	G5	S1		T	Wet meadows and grassy roadsides over circumneutral soils
Glandularia bipinnatifida	Dakota Vervain	G5	S1			Dry prairies, as the gumbo white clay (Black Belt) openings on the Fort Valley Plateau
Glyceria acutiflora	Sharp-scaled Manna-grass	G5	S1?			Sag pond margins
Glyceria melicaria	Slender Manna-grass	G5	S1?			Swamps
Glyceria pallida	Pale Manna-grass	G5?	SH			Shallow water of sag ponds
Glyceria septentrionalis	Floating Manna-grass	G5	S1?			Cypress ponds with Hymenocallis choctawensis and Iris brevicaulis; large river floodplain sloughs
Gymnocolea inflata	A Liverwort	G5	S1			In spray zones of waterfalls, Altamaha grit outcrops.
Gymnoderma lineare	Rock Gnome Lichen	G2	S1	LE	E	Moist cliff faces
Gymnopogon brevifolius	Broad-leaved Beardgrass	G5	S2?			Calcareous glades and relict prairies; dryish clay-loam soils
Gymnopogon chapmanianus	Chapman Skeleton Grass	G3	SH			Sandy pinelands near Florida,

						perhaps with Ctenium floridanum
Habenaria quinqueseta var. quinqueseta	Michaux Orchid	G4G5T?	S1			Moist shade, Altamaha Grit outcrops; open pine woods
Hartwrightia floridana	Hartwrightia	G2	S1		T	Wet savannas; ditches, sloughs and flatwood seeps
Helenium brevifolium	Bog Sneezeweed	G3G4	S1			Seepage bogs, sometimes with Sarracenia rubra near the Fall Line
Helianthemum bicknellii	Hoary Frostweed	G5	SU			Dry, sandy, open upland forests
Helianthemum canadense	Canadian Frostweed	G5	S1?			Dry, sandy scrub in fire-suppressed longleaf pine forest
Helianthus agrestis	Southeastern Sunflower	G4?	SH			Mucky, wet soils in open flatwoods
Helianthus glaucophyllus		G3	S1			Open, oak-hickory woods above 2500 ft.
Helianthus heterophyllus	Wetland Sunflower	G4	S1			Bogs; wet pine savannas
Helianthus occidentalis	Barrens Sunflower	G5	S1?			Limestone glades and barrens; rocky or cherty soils
Helianthus smithii	Smith Sunflower	G2Q	S1			Dry open woods and thickets
Helianthus verticillatus	Whorled Sunflower	G1Q	S1	C		Remnant prairies
Heliotropium tenellum	Delicate Heliotrope	G5	S2?			Limestone glades and barrens
Helonias bullata	Swamp-pink	G3	S1	LT	T	Open swamps
Heracleum lanatum	Masterwort, Giant Parsnip	G5	S1			Northern hardwood forests and open oak forests
Herpetineuron toccoae	A Moss	G4G5	S1?			Appalachian Trail (1999), on rock in mesophytic forests.
Hexastylis shuttleworthii var. harperi	Harper's Heartleaf	G4T3	S2S3		U	Low terraces in floodplain forests; edges of bogs
Hibiscus grandiflorus	Swamp Hibiscus	G4?	SH			Tidal marshes, coastal flatwoods; wet savannas

Hieracium scabrum	Rough Hawkweed	G5	S2?		Upland forests; dry sandy soils
Hottonia inflata	Featherfoil	G4	S1		Sag ponds
Huperzia appalachiana	Fir Clubmoss	G4G5	S1		Seepy ledges at high elevations
Huperzia porophila	Rock Clubmoss	G4	S1		Seepy ledges
Hydrastis canadensis	Goldenseal	G4	S2	E	Rich woods in circumneutral soil
Hydrophyllum macrophyllum	Largeleaf Waterleaf	G5	S1		Rich woods in circumneutral soil
Hygrophila lacustris	Hygrophila	G5?	S1?		Shallow water of marshy shores
Hymenocallis coronaria	Shoals Spiderlily	G2Q	S2	E	Rocky shoals of broad, open rivers
Hymenophyllum tayloriae	Taylor Filmy Fern	G1G2	S1		Wet ledges along the Chattooga River
Hypericum adpressum	Bog St. Johnswort	G3	S2?		Swamps
Hypericum buckleii	Blue Ridge St. Johnswort	G3	S1		High elevation rocky crevices
Hypericum denticulatum var. denticulatum	St. Johnswort	G5T?Q	S1		Bogs, seeps, and moist pine savannas
Hypericum dolabriforme	Glade St. Johnswort	G4	S3		Limestone glades and barrens
Hypericum sp. 3	Georgia St. Jonhswort	G2G3	S2S3		seepage bogs; roadside ditches
Hypericum sphaerocarpum	Barrens St. Johnswort	G5	S1		Limestone barrens
Hypnum cupressiforme var. filiforme	A Moss	G5T?	S2?		Hanging as green threads from rocks or bark, perhaps above 3800 ft.
Ilex amelanchier	Serviceberry Holly	G4	S2		Wet, sandy thickets; cypress-gum swamps
Ilex cuthbertii	Cuthbert Holly	G1?	SH		Open, upland forests, circumneutral
Illicium floridanum	Florida Anise-tree	G5	S1	E	Steepheads, floodplain forests
Illicium parviflorum	Yellow Anise-tree	G2	SH		Evergreen hammocks, bayheads
Ipomoea	Large-stem	G3G5	S1?		Exposed sandy

macrorhiza	Morning-glory					soils
Iris brevicaulis	Lamance Iris	G4	S1			Bogs, seeps, marshy shores and floodplains; often hidden in taller vegetation due to its low stature
Iris tridentata	Savanna Iris	G3G4	S2?			Wet savannas, flatwoods, cypress pond margins
Isoetes appalachiana	Bigspore Engelmann's Quillwort	G4	S1			Shallow water (one foot deep) of slow moving streams; mucky stream margins, periodically droughty
Isoetes boomii	Boom Quillwort	G1	S1			Shallow water (one foot deep) of slow moving streams
Isoetes butleri	Glade Quillwort	G4	S1			Limestone glades
Isoetes hyemalis	Quillwort	G2G3	S1			In blackwater streams; also emergent on sandy creek banks in deciduous swamps
Isoetes junciformis	Rush Quillwort	G1?Q	S1?			Low, seasonally flooded swales
Isoetes melanopoda	Black-footed Quillwort	G5	S1?			Clayey soils in low woods; sandstone or granite outcrop seeps
Isoetes melanospora	Black-spored Quillwort	G1	S1	LE	E	Vernal pools on granite outcrops
Isoetes tegetiformans	Mat-forming Quillwort	G1	S1	LE	E	Vernal pools on granite outcrops
Isoetes valida	Carolina Quillwort	G4?	S1			North Georgia seeps, shallow pools, sluggish streams
Isotria medeoloides	Small Whorled Pogonia	G2	S2	LT	T	Mixed hardwood-pine forests with open understory; history of nearby heavy logging, homesite or road clearing activity
Jamesianthus alabamensis	Jamesianthus	G3	S1			Streambanks, in circumneutral soil

Jeffersonia diphylla	Twinleaf	G5	S1	E	Mesic deciduous forests over limestone
Juglans cinerea	Butternut (nut-bearing Only)	G3G4	S2		Openings in bottomland forests and in the mesophytic hardwood forests of rich mountain coves
Juncus filipendulus	Texas Plains Rush	G5	S2?		Remnant prairies; limestone barrens
Juncus gymnocarpus	Naked-fruit Rush	G4	S2S3		Seepy streamsides; open swamps; mountain bogs
Juniperus communis var. depressa	Ground Juniper	G5T5	S1		Gneiss ledges
Justicia angusta	Narrowleaf Water-willow	G3Q	SH		Roadside ditches; perhaps with Hartwrightia in shallow sloughs and wet savannas
Kalmia carolina	Carolina Bog Myrtle	G4	S1		Open swamps and wet meadows; mountain bogs and Atlantic white-cedar swamps
Lachnocaulon beyrichianum	Southern Bog-button	G2G3	S1		Flatwoods
Lathyrus palustris	Marsh Wild Pea	G5	S1?		Alluvial meadows, floodplain forests
Leavenworthia exigua var. exigua	Gladecress	G4T3	S2	T	Limestone glades
Leavenworthia uniflora	Gladecress	G4	S1		Limestone glades
Lechea deckertii	Deckert Pinweed	G4G5	S1?		Scrub
Leiophyllum buxifolium	Sand-myrtle	G4	S1		High altitude rocky ledges
Leitneria floridana	Corkwood	G3	S1		Swamps; sawgrass-cabbage palmetto marshes
Lejeunea blomquistii	Blomquist Leafy Liverwort	G1G2	SH		Waterfall spray zones
Leucothoe	Recurved Dog-	G4G5	S1		Rocky open upland

recurva	hobble					forests
Liatris chapmanii	Chapman Gay-feather	G5	SH			Scrub
Liatris pauciflora	Few-flower Gay-feather	G4G5	S2?			Sandridge scrub
Liatris secunda	Sandhill Gay-feather	G4G5	S1?			Fall line sandhills
Liatris squarrosa var. hirsuta	Glade Gay-feather	G5T4?	S2?			Glades and barrens over basic rock
Liatris tenuifolia var. quadriflora	Blazing Star	G4G5T4T5	S1?			Open oak or pine woods
Lilaeopsis carolinensis	Carolina Lilaeopsis	G3G5	SH			saltwater marshes and muddy shores
Lilium canadense	Canada Lily	G5	S2?			Openings in rich woods
Lilium michiganense	Michigan Lily	G5	S1			Remnant wet prairies and calcareous flatwoods
Lilium philadelphicum	Wood Lily	G5	S1			Wet meadows over sandstone
Lindera melissifolia	Pondberry	G2	S1	LE	E	Pond margins and wet savannas
Lindera subcoriacea	Bog Spicebush	G2	S1?			Bayheads; seepy forested slopes
Lindernia saxicola	Rock False Pimpernel	G1?Q	SH		E	Rocky streamsides, sometimes submerged
Linum sulcatum var. harperi	Harper Grooved Flax	G5T2	SH			Dry pinelands
Listera australis	Southern Twayblade	G4	S2			Poorly drained circumneutral soils
Listera smallii	Appalachian Twayblade	G4	S2			Moist rhododendron thickets
Lithospermum latifolium	Broadleaf Gromwell	G4	S1			Mixed deciduous hardwood forests over limestone
Litsea aestivalis	Pondspice	G3	S2		T	Cypress ponds; swamp margins
Lobelia boykinii	Boykin Lobelia	G2G3	S2S3			Cypress ponds, sometimes with Oxypolis canbyi; Grady ponds; limesink depressions; wet savannas

Lonicera canadensis	American Fly-honeysuckle	G5	SH		Bouldery, cove hardwood forests
Lonicera dioica	Limber Honeysuckle	G5	S1		Mesic, deciduous hardwood forest openings above 3000 ft.
Lophiola aurea	Goldcrest	G4	S1?		Pine flatwoods, bogs
Lotus helleri	Carolina Birdfoot-trefoil	G5T3	S1		Clayey soil over ultramafic rock; post oak-blackjack oak savannas
Ludwigia spathulata	Creeping Smallflower Seedbox	G3G4	S2S3		Exposed shores and bottoms of sinkhole ponds, cypress-gum ponds, bogs; also disjunct on granite outcrop quarry pools
Lycium carolinianum	Carolina Wolfberry	G4	S1		Coastal sand spits
Lycopodium clavatum	Ground Pine	G5	S1		Moist oak forests
Lycopus americanus	American Bugleweed	G5	S1		Wet meadows and old fields along Conasauga River
Lygodium palmatum	Climbing Fern	G4	S2		Acid soils of thickets and open upland forests
Lysimachia fraseri	Fraser's Loosestrife	G2	S1S2	R	Moist, open, bouldery gravel bars and streambanks; edges of sandstone and granite outcrops
Lysimachia loomisii	Loomis Loosestrife	G3	SH		Wet savannas, flatwoods, and margins of Carolina bays (pocosins)
Lysimachia terrestris	Bog Candles	G5	S1		Mountain seeps, wet meadows; streambanks
Lythrum curtissii	Curtiss' Loosestrife	G1	S1	T	Openings in calcareous swamps
Macbridea caroliniana	Carolina Bogmint	G2G3	S1		Bogs; marshes; alluvial woods
Macranthera	Flame Flower	G3	S1?		Wet, sandy

flammea						thickets; pitcherplant bogs
Malaxis spicata	Florida Adders-mouth	G4?	S1			Low hammocks; spring-fed river swamps
Marshallia mohrii	Coosa Barbara Buttons	G3	S2	LT	T	Remnant Coosa Valley prairies; maintained rights-of-way
Marshallia ramosa	Pineland Barbara Buttons	G2	S2		R	Altamaha Grit outcrops; open forests over ultramafic rock
Marshallia trinervia	Broadleaf Barbara's-buttons	G3	S1S2			Streamsides in open, bouldery gravel bars and washed, sandy banks
Matelea alabamensis	Alabama Milkvine	G2	S1		T	Open bluff forests; mesic margins of longleaf pine sandridges
Matelea obliqua	Limerock Milkvine	G4?	S2			Mesic deciduous hardwood forests over limestone
Matelea pubiflora	Trailing Milkvine	G3G4	S2		R	Exposed sandy soils; sandridges
Mecardonia acuminata var. microphylla	Littleleaf Mecardonia	G5T?	S1			Edges of pond margins, sometimes with Lindera melissifolia
Melanthium latifolium	Broadleaf Bunchflower	G5	S2?			Mesic deciduous hardwood forests
Melanthium woodii	Ozark Bunchflower	G5	S2		R	Mesic hardwood forests over basic soils
Menziesia pilosa	Minniebush	G4G5	S1			Rocky ridgetops
Mertensia virginica	Virginia Bluebells	G5	S1S2			Floodplain forests in limestone valleys
Micromeria brownei var. pilosiuscula	Savory	G5T?	S1?			Floodplain forests; muddy banks
Mikania cordifolia	Heartleaf Climbing Hempweed	G5	S1			Bottomland hardwoods and hammocks near coast

Mirabilis albida	Pale Umbrella-wort	G5	S1?		Sandhills of SW Georgia with Warea sessiliflora
Mitreola angustifolia	Narrowleaf Miterwort	G4G5	S1S3		Cypress-gum depressions, wet pine flatwoods
Monotropsis odorata	Sweet Pinesap	G3	S1		Upland forests
Muhlenbergia sobolifera	Sprouting Muhly	G5	S1?		Dry, wooded limestone slopes
Muhlenbergia sylvatica	Woodland Muhly	G5	S1?		Calcareous streambanks
Muhlenbergia torreyana	Torrey Dropseed	G3	SH		Seasonally inundated pond shores, swales and savannas
Myrica inodora	Odorless Bayberry	G4	S2?		Bayheads, titi swamps; forests with pond pine
Myriophyllum laxum	Lax Water-milfoil	G3	S2S3	T	Bluehole spring runs; shallow, sandy, swift-flowing creeks; clear, cool ponds
Najas filifolia	Narrowleaf Naiad	G1	S1		Lakes
Nestronia umbellula	Indian Olive	G4	S2	T	Mixed with dwarf shrubby heaths in oak-hickory-pine woods; often in transition areas between flatwoods and uplands
Neviusia alabamensis	Alabama Snow-wreath	G2	S1	T	Along wet weather streams over limestone
Oldenlandia boscii	Bluets	G5	S3?		Cypress pond margins; exposed pond bottoms in limesinks; sag pond margins; sometimes ditches
Oligoneuron riddellii	Riddell's Goldenrod	G5	S1		Wet, calcareous prairies
Onosmodium molle ssp. occidentale	Marble-seed	G4G5T4?	S1		Limestone glades and adjacent woods
Ophioglossum engelmannii	Limestone Adder-tongue	G5	S2S3		Rocky limestone glades; rarely on

	Fern					granite outcrops (Heggies Rock)
Orbexilum virgatum	Slender Leather-root	G1	SH			Sandridges
Oxalis montana	White Woodsorrel	G5	S1?			Bouldery woods; northern hardwoods
Oxypolis canbyi	Canby's Dropwort	G2	S2	LE	E	Cypress ponds and sloughs; wet savannas
Oxypolis ternata	Savanna Cowbane	G3	S2			Wet pine savannas and bogs
Pachysandra procumbens	Allegheny-spurge	G4G5	S1S2			Mesic hardwood forests over basic soils
Palafoxia integrifolia	Palafoxia	G3G4	S2?			Sandy pine-oak scrub
Palamocladium leskeoides	A Moss	G3G5	S1?			Rock face (dry limestone?), Lookout Mountain
Panax quinquefolius	American Ginseng	G3G4	S3			Mesic hardwood forests; cove hardwood forests
Panax trifolius	Dwarf Ginseng	G5	S1			Mesic hardwood-coniferous forests
Panicum hirstii	Hirst's Panic Grass	G1	SH	C	E	Cypress ponds, wet savannas and sloughs
Panicum neuranthum	Panic Grass	G5?	S1?			Seasonally wet, pine savanna-pondcypress pond ecotone
Panicum tenerum	Panic Grass	G4	S1			Wet pine savannas near the coast
Parietaria pensylvanica	Pennsylvania Pellitory	G5	S1?			Dry, open, calcareous soil
Parnassia grandifolia	Largeleaf Grass-of-parnassus	G3	SH			Seepy limestone and shale ledges
Paronychia argyrocoma	Silverling	G4	S1			Sandstone and granite outcrops
Paronychia patula	Pineland Nailwort	G3G4	S1?			Dry pinelands; sandhills
Paronychia rugelii var. interior	Rugel's Nailwort	G2?T2?Q	S1?			Longleaf pine-turkey oak scrub, mostly Alapaha River drainage

Paronychia rugelii var. rugelii	Rugel's Nailwort	G2?T2?	S2?		Sandy oak barrens and streambanks
Paronychia virginica	Yellow Nailwort	G4	S1		Serpentine outcrops
Pedicularis lanceolata	Swamp Lousewort	G5	S1		Bogs and wet woods
Pediomelum sp. 2	Dixie Mountain Breadroot	G1	S1		Shallow soils over mafic (serpentine) rock, upland longleaf pine-mixed oak savanna and powerline rights-of-way
Pediomelum subacaule	Nashville Breadroot	G4	S2		Limestone glades
Peltandra sagittifolia	Arrow Arum	G3G4	S2?		Swamps; wet hammocks on pristine sphagnum mats
Penstemon calycosus	Long-sepal Beardtongue	G5	SH		Limestone ledges and streambanks
Penstemon dissectus	Grit Beardtongue	G2	S2	R	Altamaha Grit outcrops and adjacent pine savannas; rarely sandridges
Penstemon pallidus	Beardtongue	G5	S1?		Limestone & shale barrens
Penstemon smallii	Small's Beardtongue	G3	S1?		Open woods on rocky slopes and bluffs in circumneutral soil
Pentodon pentandrus	Pentodon	G5?	S1?		Wet meadows; pond edges
Phacelia fimbriata	Fringed Phacelia	G4	S1		Mesic hardwood forests over basic soils
Phacelia purshii	Miami-mist	G5	S1		Mesic hardwood forests over basic soils
Phaseolus polystachios var. sinuatus	Trailing Bean-vine	G4T3?	S2?		Sandhills; dry pinelands and hammocks
Philadelphus pubescens	Hairy Mockorange	G5?	S1		Limestone ledges and rocky banks
Phlebodium aureum	Goldfoot Fern	G5	S1		Exposed calcareous soil;

					also epiphytic on live oak and sabal palmetto (cabbage palm)
Phlox amplifolia	Broadleaf Phlox	G3G5	S1		Mesic hardwood forests over basic soils
Phyla lanceolata	Fog-fruit	G5	S1?		Low woods along streams
Physalis arenicola	Sandhill Groundcherry	G3?	S1S2		Cypress-heads; scrub thickets
Physostegia angustifolia	Narrowleaf Obedient Plant	G4G5	S1?		Calcareous, seasonally wet, grassy openings of Southwest Georgia, sometimes with Lythrum curtissii
Physostegia leptophylla	Tidal Marsh Obedient Plant	G4?	S2S3	T	Freshwater tidal marshes; disjunct in wet savannas of extreme SW Georgia
Piloblephis rigida	Pennyroyal	G3G4	S1		Myrtle oak scrub
Pilularia americana	American Pillwort	G5	S2		Granite outcrops; seasonally exposed muddy shores
Pinguicula primuliflora	Clearwater Butterwort	G3G4	S1	T	In shallow, sandy, clearwater streams and seeps; Atlantic whitecedar swamps
Pityopsis oligantha	Narrow-leaved Golden-aster	G2G4	S1S2		Flatwoods, bogs and seeps of Southwest Georgia
Pityopsis pinifolia	Sandhill Golden-aster	G4	S2	T	Sandhills near fall line
Plagiochila caduciloba	Gorge Leafy Liverwort	G2	S1?		Moist cliff faces
Plagiochila sharpii	Sharp's Leafy Liverwort	G2G4	S1?		Moist cliff faces and spray zones
Plagiochila sullivantii	Sullivant's Leafy Liverwort	G2	SH		Seepy rock cliffs
Plagiomnium carolinianum	Mountain Wavy-leaf Moss	G3	S2?		Moist cliff faces
Plantago sparsiflora	Pineland Plantain	G3	S2		Open, wet pine savannas; shallow

						ditches and seeps, especially in mowed rights-of-way
Platanthera blephariglottis var. blephariglottis	Northern White Fringed Orchis	G4G5T4?	S1?			Bogs and seeps; wet savannas
Platanthera blephariglottis var. conspicua	Southern White Fringed Orchid	G4G5T3T4	S2?			BOGS, SEEPS, ROADSIDES, WET SAVANNAS
Platanthera chapmanii	Chapman's Yellow Fringed Orchid	G4?	SH			OPEN, WET MEADOWS; PINE FLATWOODS
Platanthera flava var. herbiola	Leafy Southern Tubercled Orchid	G4T4Q	S1?			Red maple-gum swamps
Platanthera grandiflora	Large Purple Fringed Orchid	G5	S1			Wet thickets; seepy open northern hardwood forests
Platanthera integra	Yellow Fringeless Orchid	G3	S2			Wet savannas, pitcherplant bogs
Platanthera integrilabia	Monkeyface Orchid	G2G3	S1S2	C	T	Red maple-gum swamps; peaty seeps and streambanks with Parnassia asarifolia and Oxypolis rigidior
Platanthera nivea	Snowy Orchid	G5	S2S3			Wet savannas, pitcherplant bogs
Platanthera peramoena	Purple Fringeless Orchid	G5	S1			Wet meadows, openings among bottomland hardwoods
Platanthera psycodes	Small Purple-fringe Orchid	G5	S1?			Wet thickets; seepy, open, northern hardwood forests
Platyhypnidium pringlei	Pringle's Platyhypnidium	G2G3	S1			Seepy rock cliffs
Polemonium reptans	Jacobs Ladder	G5	S1			Mesic hardwood forests over basic soils
Polygala balduinii	White Milkwort	G4	S1?			Wet pine savannas
Polygala	Georgia	G3G4	S1			Oak-pine scrub

leptostachys	Milkwort			
Polygonum amphibium var. emersum	Water Smartweed	G5T5	S1	MARSHY MARGIN OF FRESHWATER POND WITH LEITNERIA FLORIDANA
Polygonum arifolium	Halberd-leaf Tear-thumb	G5	S1	Marshes and wet thickets
Polygonum glaucum	Sea-beach Knotweed	G3	SH	Coastal beaches in dune depressions and among protected accumulations of beach wrack
Polygonum meisnerianum var. beyrichianum	Meisner's Tear-thumb	G5?T5?	S1?	Shallow water in and along the Aucilla River
Polymnia laevigata	Tennessee Leafcup	G3	S1	Bouldery slopes
Ponthieva racemosa	Shadow-witch Orchid	G4G5	S2?	Calcareous swamps; marly outcrops
Portulaca biloba	Grit Portulaca	G1G2	S1	Altamaha Grit outcrops
Portulaca umbraticola ssp. coronata	Wingpod Purslane	G5T2	S2	Granite outcrops; Altamaha Grit outcrops
Potamogeton amplifolius	Bigleaf Pondweed	G5	S1	Sluggish streams; ponds
Potamogeton pusillus	Pigmy Pondweed	G5	S1?	Shallow creeks and rivers over calcareous bedrock
Prenanthes barbata	Flatwoods Rattlesnake-root	G3	S2	Limestone glades and barrens, edges of remnant prairies
Prunus mexicana	Mexican Plum	G4G5	S1?	Remnant prairies
Prunus pensylvanica	Fire Cherry	G5	S2	Rocky summits, especially following fire
Prunus virginiana	Chokecherry	G5	S1	Boulderfields in northern hardwood forests
Psilotum nudum	Whisk Fern	G5	S1	Epiphytic in hammocks, Okefenokee Swamp; on palm

						trunks in coastal habitats; rarely in lawns and sandy openings
Pteroglossaspis ecristata	Wild Coco	G2	S1			Grassy saw palmetto barrens; longleaf pine grasslands, sometimes with Schwalbea americana
Ptilimnium costatum	Eastern Bishopweed	G3G4	S2?			Remnant wet prairies; bottomland hardwood forests
Ptilimnium nodosum	Harperella	G2	S1	LE	E	Granite outcrop seeps; shallow seasonal ponds in limesink depressions
Ptilimnium sp. 1	Mock Bishop-weed	G1	SH			Tidal freshwater marshes
Pycnanthemum albescens	White-leaved Mountain-mint	G5	S1S2			Open, mesic woods
Pycnanthemum beadlei	Beadle's Mountain-mint	G2G4	S2?			ROCKY OPEN WOODS; EDGES OF ROCK OUTCROPS
Pycnanthemum curvipes	Stone Mountain Mint	G3	S2			Rocky, upland oak-hickory forests
Pycnanthemum virginianum	Virginia Mountain-mint	G5	S1			Wet meadows and barrens
Quercus arkansana	Arkansas Oak	G3	S2S3			Sandy upper ravine slopes
Quercus austrina	Bluff White Oak	G5	S3?			Bluff forests, often in circumneutral soils; floodplain hammocks; edges of Altamaha Grit outcrops
Quercus chapmanii	Chapman Oak	G4G5	S2			Sandridges; dunes; oak-pine scrub
Quercus imbricaria	Shingle Oak	G5	S1			Sandy, moist hardwood flats and headwater slopes
Quercus oglethorpensis	Oglethorpe Oak	G3	S2		T	Broad River bottomlands; upland seepage swamps over

						Iredell and Enon soils with seasonally wet clay beds
Quercus palustris	Pin Oak	G5	SH			Floodplain forests; margins of sag ponds
Quercus prinoides	Dwarf Chinkapin Oak	G5	S2			Upland oak-hickory-pine forests; usually over basic soils
Quercus sinuata	Durand Oak	G5	S1S2			Bluff forests; calcareous slopes near streams
Rhexia aristosa	Awned Meadowbeauty	G3	S2			Pond margins and wet savannas
Rhexia nuttallii	Nuttall Meadowbeauty	G4?	S1?			Pine flatwoods; bogs
Rhexia parviflora	Small-flowered White Meadowbeauty	G2	SH			Limesink pond margins, perhaps in openings under pond-cypress
Rhododendron prunifolium	Plumleaf Azalea	G3	S3		T	Mesic hardwood forests in ravines and on sandy, seepy streambanks
Rhus michauxii	Dwarf Sumac	G2	S1	LE	E	Open forests over ultramafic rock
Rhus typhina	Staghorn Sumac	G5	S1			Open montane forests
Rhynchospora alba	Northern White Beaksedge	G5	S1			Mountain bogs and seeps; disjunct in Okefenokee Swamp, as is cottongrass (Eriophorum)
Rhynchospora crinipes	Bearded Beaksedge	G1	S1			Streambanks and shallow streambeds
Rhynchospora culixa	Georgia Beaksedge	G1Q	S1			Pine savannas; flatwoods
Rhynchospora decurrens	Swamp-forest Beaksedge	G3G4	S1?			Swamps
Rhynchospora harperi	Harper's Beaksedge	G4?	S1S2			Cypress pond margins and wet savannas; limesink depression ponds (dolines)
Rhynchospora	Southern White	G3	S1?			Peaty, sandhill

macra	Beaksedge				seepage slopes; streamhead pocosins
Rhynchospora microcarpa	Southern Beaksedge	G5	S1S2		clay-based Carolina bays; swamps
Rhynchospora oligantha	Feather-bristle Beaksedge	G4	S1?		Bogs; sea-level fens; wet savannas
Rhynchospora pleiantha	Coastal Beaksedge	G2	SH		Margins of limesink depression ponds (dolines)
Rhynchospora punctata	Pineland Beaksedge	G1?	S1?		Wet savannas, pitcherplant bogs
Rhynchospora scirpoides	Long-beak Baldrush	G4	S2?		Floating mats in ponds; pond margins
Rhynchospora solitaria	Autumn Beakrush	G1	S1		Wet, sandy, peaty depressions
Rhynchospora stenophylla	Chapman's Beakrush	G4	S2		Wet, sandy, peaty depressions; Chamaecyparis seeps
Rhynchospora thornei	Thorne's Beakrush	G2	S2		Margins of limesink ponds; moist limestone barrens, wet prairies
Rhynchospora torreyana	Torrey Beakrush	G4	S1?		Bogs; wet savannas
Ribes curvatum	Granite Gooseberry	G4	S2		Rocky upland forests; bouldery mesic slopes
Rudbeckia auriculata	Swamp Black-eyed Susan	G1	S1		Swampy woods
Rudbeckia fulgida var. speciosa	Showy Orange Coneflower	G5T4?	S1?		Limestone barrens; open woods over basic soils
Rudbeckia grandiflora	Largeflower Coneflower	G5	SH		Limestone glades and barrens
Rudbeckia heliopsidis	Little River Black-eyed Susan	G2	S1		Limestone or sandstone barrens and streamsides
Ruellia noctiflora	Night-blooming Wild Petunia	G2	SH		Open, slash pine flatwoods
Sabatia capitata	Cumberland Rose Gentian	G2	S2	R	Meadows over sandstone or shale
Sageretia	Tiny-leaf	G4	S1	T	Calcareous bluff

minutiflora	Buckthorn					forests; maritime forests over shell mounds
Sagittaria platyphylla	Ovate-leaved Arrowhead	G5	S1?			Marshes and shores
Sagittaria secundifolia	Little River Water-plantain	G1	S1	LT	T	Crevices in sandstone in fast flowing streams
Salix floridana	Florida Willow	G2	S1		E	Spring runs; seepy, sphagnous wetlands with Eleocharis tortilis, Itea, Alnus, Orontium, Arnoglossum sulcatum
Sambucus racemosa ssp. pubens	Red Elderberry	G5T4T5	S1			Boulderfields; high elevation summits (e.g.; Hightower Bald, Brasstwon Bald)
Sanguisorba canadensis	Canada Burnet	G5	S1		T	Seepy meadows and thickets
Sanicula trifoliata	Beak-fruit Sanicle	G4	S1?			Mesic hardwood forests
Sapindus saponaria	Soapberry	G5	S1			Shell mound forests
Sarracenia flava	Yellow Flytrap	G5?	S3S4		U	Wet savannas, pitcherplant bogs
Sarracenia leucophylla	Whitetop Pitcherplant	G3	S1		E	Wet savannas, pitcherplant bogs
Sarracenia minor	Hooded Pitcherplant	G4	S4		U	Wet savannas, pitcherplant bogs
Sarracenia oreophila	Green Pitcherplant	G2	S1	LE	E	Wet meadows; upland bogs
Sarracenia psittacina	Parrot Pitcherplant	G4	S2S3		T	Wet savannas, pitcherplant bogs
Sarracenia purpurea	Purple Pitcherplant	G5	S1		E	Swamps, wet rhododendron thickets
Sarracenia rubra	Sweet Pitcherplant	G3	S2	(PS)	E	Atlantic white cedar swamps; wet meadows
Saxifraga careyana	Carey Saxifrage	G3	SH			Moist rock ledges
Saxifraga texana	Texas Saxifrage	G4	S1			Granite outcrops
Schisandra glabra	Bay Starvine	G3	S2		T	Rich woods on stream terraces and

						lower slopes
Schoenocaulon dubium	Florida Feather-shank	G3?	SH			Pine savannas
Schoenolirion elliottii	White Sunnybell	G3	S1?			Wet savannas
Schwalbea americana	Chaffseed	G2	S1	LE	E	Open pinelands, as in well-managed, somewhat moist longleaf pine-wiregrass forests seeps
Scirpus cespitosus	Tufted Club-rush	G5	S1			Seepy ledges
Scirpus cylindricus	Salt-marsh Bulrush	G5	SH			Brackish marshes
Scirpus erismanae	Bulrush	G?Q	S1?			Pond shores in peaty sands
Scirpus etuberculatus	Canby's Club-rush	G3G4	S1S2			Marshes; shallow ponds; peaty swamps, as Okefenokee Swamp and Atlantic whitecedar swamps
Scirpus expansus	Woodland Bulrush	G4	S1S2			Marshes and streambeds
Scirpus hallii	Hall Bulrush	G2	SH			Pond shores in peaty sands
Scutellaria altamaha		G2G3	S1?			Sandy, deciduous woods
Scutellaria arenicola	Sandhill Skullcap	G3G4	SH			Sandy scrub
Scutellaria leonardii	Glade Skullcap	G4Q	S2			Limestone glades
Scutellaria mellichampii	Skullcap	GNRQ	S1?			Sandy deciduous woods
Scutellaria montana	Large-flowered Skullcap	G2	S2	LT	T	Mesic hardwood-shortleaf pine forests; usually mature forest with open understory, sometimes without a pine component
Scutellaria nervosa	Bottomland Skullcap	G5	S1			Floodplain forests
Scutellaria ocmulgee	Ocmulgee Skullcap	G2	S2		T	Mesic hardwood forests; bluff forests

Scutellaria saxatilis	Rock Skullcap	G3	S1		
Scutellaria serrata	Showy Skullcap	G4G5	S1		
Sedum nevii	Nevius' Stonecrop	G3	S1	T	Gneiss ledges on river bluffs
Sedum pusillum	Granite Stonecrop	G3	S3	T	Granite outcrops, often in mats of Hedwigia moss under Juniperus virginiana
Selaginella ludoviciana	Louisiana Spikemoss	G3G4	S1?		Swamp margins; wet meadows
Senecio millefolium	Blue Ridge Golden Ragwort	G2	S1	T	High elevation rock outcrops
Senecio pauperculus	Meadow Golden Ragwort	G5	S1?		Moist meadows and prairies
Shortia galacifolia	Oconee Bells	G2	SE1?	E	Mesic forests with mountain laurel and rhododendron
Sibbaldiopsis tridentata	Three-tooth Cinquefoil	G5	S1	E	Rocky summits
Sida elliottii	Elliott's Fanpetals	G4G5	S2?		Dry or moist openings in sandy woods; limesink pond margins, limestone glades and barrens
Sideroxylon alachuense	Silver Buckthorn	G1	S1?		Sandy hammocks; islands in Okefenokee Swamp; shell middens
Sideroxylon sp. 1	Ohoopee Bumelia	G3Q	S3		Dry longleaf pine woods with oak understory; often hidden in wiregrass
Sideroxylon thornei	Swamp Buckthorn	G2	S2	E	Forested limesink depressions; calcareous swamps
Silene caroliniana	Carolina Pink	G5	S2?		Granite outcrops and sandhills near the Ogeechee and Savannah Rivers
Silene ovata	Mountain Catchfly	G2G3	S1S2		Mesic deciduous or beech-magnolia forests over

						limestone; bouldery, high elevation oak forests
Silene polypetala	Fringed Campion	G2	S2	LE	E	Mesic deciduous forests
Silene regia	Royal Catchfly	G3	S1		R	Limestone barrens; remnant prairies
Silene rotundifolia	Roundleaf Catchfly	G4	S1			Moist sandstone ledges and cliffs, often with Heuchera villosa
Silphium mohrii	Cumberland Rosinweed	G3?Q	S1?			Rocky hardwood forests
Silphium radula	Rosinweed	G4	SH			Rocky hardwood forests
Sium floridanum	Florida Water-parsnip	G1Q	S1?			Calcareous swamps; floodplains
Smilax lasioneuron	Carrion-flower	G5	S2?			Pine-oak-hickory forests; bluff forests
Smilax leptanthera	Catbrier	GHQ	SH			Deciduous forests
Solanum pumilum	Dwarf Horse-nettle	G5T1	SH			Thickets; calcareous barrens
Solidago porteri	Porter Goldenrod	GHQ	SH			Upland forests
Solidago simulans	Cliffside Goldenrod	G1	S1			Seepy summits of granite domes; moist, steep, rocky slopes and cliffs
Solidago speciosa var. rigidiuscula	Goldenrod	G5T4	S1			Limestone barrens
Solidago uliginosa var. uliginosa		G4G5T4T5	S1			
Sorbus americana	American Mountain-ash	G5	S1			Grassy balds; northern hardwood forests
Spartina pectinata	Prairie Cordgrass	G5	SE1?			Relict prairies in calcareous flatwoods
Spermacoce glabra	Smooth Buttonweed	G4G5	S2?			Alluvial woods; margins of sloughs and oxbow lakes
Spermolepis	Rough-fruited	G5	S1			Relict prairies in

inermis	Spermolepis					the Black Belt over marly Oktibbeha soils
Spiraea alba var. latifolia	Broadleaf White Spirea	G5T5	S1			Mountain bogs; roadside seepage slopes
Spiraea tomentosa	Hardhack	G5	S1			Wet meadows
Spiraea virginiana	Virginia Spirea	G2	S1	LT	T	Bouldery gravel bars and ledges along major streams
Spiranthes brevilabris	Downy Slender Ladies-tresses	G2G3	SH			Wet, pine savannas and flatwoods, well-managed by fire
Spiranthes eatonii	Eaton's Ladies-tresses	G2G4	S2?			Cemeteries, roadsides; drier pine flatwoods
Spiranthes floridana	Florida Ladies-tresses	G3G4	S1?			Wet savannas; mowed grassy openings in Okefenokee area
Spiranthes longilabris	Giant Spiral Ladies-tresses	G3	S1			Pine flatwoods, wet savannas, low hammocks with saw palmetto
Spiranthes magnicamporum	Great Plains Ladies-tresses	G4	S1		E	Limestone glades
Spiranthes ovalis var. erostellata	Self-pollinating Oval Ladies-tresses	G5?T4?	S2S3			SEEPY MARGINS OF SMALL STREAMS; FLOODPLAIN WOODS
Spiranthes sylvatica	Pale Green Ladies-tresses	G?	S1?			Live oak hammocks; other open woodlands
Sporobolus heterolepis	Prairie Dropseed	G5	S1			Calcareous glades and barrens
Sporobolus pinetorum	Pineland Dropseed	G3	S2?			Wet savannas with wiregrass
Sporobolus teretifolius	Wire-leaf Dropseed	G2?	S2?			Longleaf pine-wiregrass savannas, pitcherplant bogs
Stachys eplingii	Epling's Hedge-nettle	G5	S1?			Mesic forests, wet meadows, over mafic or calcareous

						soils
Stachys hispida	Hispid Hedge-nettle	G4Q	S2?			Wet meadows, mesic forests, swampy woods, seeps, and boulderfields
Stachys hyssopifolia var. lythroides	Tallahassee Hedge-nettle	G5T1Q	S1			Moist longleaf pine savannas; roadside ditches
Stachys latidens	Broad-toothed Hedge-nettle	G4G5Q	S2?			Cove hardwoods and mesic forests
Stachys nuttallii	Nuttall's Hedge-nettle	G5?	S2			Mesic hardwood forests, mostly calcareous
Stewartia malacodendron	Silky Camellia	G4	S2		R	Along streams on lower slopes of beech-magnolia or beech-basswood-Florida maple forests
Stokesia laevis	Stokes Aster	G4	S1			Pitcherplant bogs
Streptopus roseus	Rosy Twisted Stalk	G5	S1			High elevations boulderfields
Stylisma pickeringii var. pickeringii	Pickering's Morning-glory	G4T2T3	S2		T	Open, dry, oak scrub of sandhills
Stylophorum diphyllum	Celandine Poppy	G5	S1			Mesic hardwood forests over limestone
Symphyotrichum pratense	Silky Aster	G5TNR	S1			Limestone glades
Symphyotrichum sericeum	Silky Aster	G5	S1			Limestone glades
Teloschistes exilis	Orange Fructicose Bark Lichen	G3G5	S1?			Relict Blackland prairies; on bark, especially on stunted Campsis radicans and in Cornus asperifolia thickets
Tephrosia chrysophylla	Sprawling Goats Rue	G4G5	S1			Dry, sandy scrub
Tephrosia mohrii	Dwarf Goats Rue	G3	S1?			Scrub; longleaf pine-wiregrass savannas
Thalia dealbata	Flag	G4	S1			Brackish sloughs and marshes
Thalictrum	Cooley's	G1	S1	LE	E	Pond margins and

cooleyi	Meadowrue				wet savannas
Thalictrum coriaceum	Leatherleaf Meadowrue	G4	S1?		Rich woods
Thalictrum debile	Trailing Meadowrue	G2	S1	T	Mesic hardwood forests over limestone
Thalictrum subrotundum	Roundleaf Meadowrue	G1G2Q	SH		Swamp edges, streamsides; mesic ravine forests
Thaspium chapmanii	Creamy Meadow-parsnip	G?	S3?		Hardwood forests and glades, near edges of gumbo flats and rocky outcrops of limestone or amphibolite
Thaspium pinnatifidum	Cutleaf Meadow-parsnip	G2G3	S1		Limestone outcrops and barrens
Thelypteris ovata	Ovate Maiden Fern	G3G5	S2S3		Calcareous hammocks; limesinks; mesic hardwood forests
Thermopsis fraxinifolia	Ash-leaf Bush-pea	G3?Q	S2?		Oak and oak-pine ridge forests
Thermopsis mollis	Downy Bush-pea	G3G4	S1?		Dry slopes and ridges; mostly in open pine-oak forests
Thermopsis villosa	Aaron's Rod	G3?	S1?		Mesic forests, floodplains and roadsides; mostly in sandy soils
Tillandsia bartramii	Bartram's Air-plant	G4	S2		Epiphytic in bay swamps, freshwater tidal swamps; beech-magnolia bluff forests
Tillandsia fasciculata	Quill-leaf Air-plant	G5	S1		Epiphytic on evergreen oaks
Tillandsia recurvata	Ball-moss	G5	S1	T	Epiphytic in live oak maritime forests
Tillandsia setacea	Pine-needle Air-plant	G5	S1?		Epiphytic in bluff forests on evergreen hardwoods
Tofieldia	Sticky False	G5	SH		Open peaty

glutinosa	Asphodel					swamps
Torreya taxifolia	Florida Torreya	G1	S1	LE	E	Rich ravines in extreme Southwest Georgia
Tradescantia roseolens	Rosy Spiderwort	G5	S2?			Dry, sandy woods
Tragia cordata	Heartleaf Nettle Vine	G4	S2?			Dry, usually rocky, calcareous woods; also relict prairie openings on the Fort Valley Plateau
Trepocarpus aethusae	Trepocarpus	G4G5	S2?			Floodplain forests
Triadenum tubulosum	Broadleaf Marsh St. Johnswort	G4?	S1S3			Swamps
Trichomanes boschianum	Appalachian Filmy Fern	G4	S1			Acidic ledges and overhangs
Trichomanes petersii	Dwarf Filmy Fern	G4G5	S2			Acidic boulders, ledges and overhangs; Altamaha Grit outcrops
Tridens carolinianus	Carolina Redtop	G3	S1?			Dry, open mixed oak-pine forests of the Fall Line Sandhills
Trientalis borealis	Northern Starflower	G5	S1S2		E	Rocky, northern hardwood forests
Trillium discolor	Pale Yellow Trillium	G2	S1S2			Mesic hardwood forests only in Savannah River watershed
Trillium flexipes	Bent Trillium	G5	S1			Mesic hardwood forests over limestone
Trillium lancifolium	Lanceleaf Trillium	G3	S3			Floodplain forests; also lower rocky slopes over basic soils
Trillium persistens	Persistent Trillium	G1	S1	LE	E	Mesic hardwood forests, upland forests
Trillium pusillum	Least Trillium	G3	S1			Red maple-blackgum swampy woods in sticky clay soils
Trillium reliquum	Relict Trillium	G2	S2	LE	E	Mesic hardwood

				forests; limesink forests; usually with Fagus and Tilia
Trillium simile	Sweet White Trillium	G3	S2	Cove hardwoods, sometimes with Rhododendron maximum
Trillium sulcatum	Barksdale Trillium	G4	S2	Mesic hardwood forests
Triosteum angustifolium	Narrowleaf Wild Coffee	G5	S1?	Mesic hardwood forests over limestone
Triosteum aurantiacum	Wild Coffee	G5	S2?	Open woodlands over circumneutral or calcareous soils
Triphora trianthophora	Three-birds Orchid	G3G4	S2?	Loamy soils of rhododendron thickets; hardwood forests
Tsuga caroliniana	Carolina Hemlock	G3	S1	Rocky bluffs
Ulmus serotina	September Elm	G4	S1	Mesic hardwood forests over limestone
Utricularia olivacea	Leafless Dwarf Bladderwort	G4	S1?	Shallow ponds, especially limesink ponds or dolines of Southwest Georgia
Utricularia resupinata	Lavender Bladderwort	G4	S1?	Pools in pine flatwoods of Southwest Georgia; also disjunct in Northeast Georgia mountain swamps
Vaccinium crassifolium	Evergreen Lowbush Blueberry	G4G5	SH	Open margins of Carolina bays
Vaccinium erythrocarpum	Bearberry	G5	S1	Mixed oak-heath forests
Veratrum viride	American False Hellebore	G5	S2	Seepy northern hardwood forests
Verbesina helianthoides	Hairy Wingstem	G5	SH	Prairies; dry woods
Verbesina walteri	Carolina Crownbeard	G3?	S1?	Moist slopes of hardwood bluffs and edges of colluvial swamps

					with calcareous substrate; along Savannah River
Viburnum bracteatum	Limerock Arrow-wood	G1	S1	E	Mesic hardwood forests over limestone
Viburnum carolinianum	Carolina Arrow-wood	G4G5Q	S1		Mountain bogs and openings in red maple-blackgum swamps
Viburnum lantanoides	Witch-hobble	G5	SH		Northern hardwood forests
Viburnum rafinesquianum var. affine	Limerock Downy Arrowwood	G5T?	S1		Limestone bluffs along major rivers
Viburnum rafinesquianum var. rafinesquianum	Downy Arrowwood	G5T4T5	S1?		Rocky woods and bluffs; both granite and limestone
Vigna luteola	Wild Yellow Cowpea	G5	S2?		Open swamps; maritime beaches and tidal flats
Viola egglestonii	Glade Violet	G4	S2		Limestone glades
Vitis palmata	Catbird Grape	G4	SH		Floodplain forests; river banks
Vitis rotundifolia var. munsoniana	Munson Grape	G5T4?	S1		Floodplain forests; blackwater streamsides
Vittaria lineata	Shoestring Fern (sporophyte)	G4	S1		Altamaha Grit outcrops; epiphytic on cabbage palms; rocky slopes
Waldsteinia lobata	Piedmont Barren Strawberry	G2	S2	T	Stream terraces and adjacent gneiss outcrops
Warea sessilifolia	Sandhill-cress	G2G4	S1		Sandhills scrub
Websteria confervoides	Algal Bulrush	G3G5	S1?		Lakes and ponds
Woodsia scopulina ssp. appalachiana	Appalachian Cliff Fern	G5T4	S1		Sandstone and shale cliffs
Xerophyllum asphodeloides	Eastern Turkeybeard	G4	S1	R	Xeric oak-pine forests
Xyris chapmanii	Chapman Yellow-eyed Grass	G3	S1?		Streamhead seepage bogs in deep muck with numerous other

						xyrids and graminoids
Xyris drummondii	Drummond Yellow-eyed Grass	G3	S1			Pine flatwoods
Xyris scabrifolia	Harper Yellow-eyed Grass	G3	S1			Sedge bogs; pitcherplant bogs; pine flatwoods
Xyris tennesseensis	Tennessee Yellow-eyed Grass	G2	S1	LE	E	Seepy margins of limestone spring runs
Zamia integrifolia	Florida Coontie	G3G4Q	SH			Maritime live oak forests
Zanthoxylum americanum	Northern Prickly-ash	G5	S1?			Rocky, openly wooded slopes; river banks and terraces
Zenobia pulverulenta	Zenobia	G4?	S1			Cypress gum pond margins and sandhill depressions
Zephyranthes simpsonii	Simpson Rain Lily	G2G3	S1			Pine flatwoods; edges of sloughs on southcentral coastal plain
Zigadenus leimanthoides	Death-camus	G4Q	S1			Sandhill bogs; pine flatwoods

NOTE: This is a working list and is constantly revised (see element occurance data disclaimer). For the latest changes, acknowledgment of numerous sources, interpretation of data, or other information connected with this list, please contact:

Greg Krakow - Data Manager
Georgia Department of Natural Resources
Wildlife Resources Division
Georgia Natural Heritage Program
2117 U.S. Highway 278 S.E.
Social Circle, Georgia 30025-4714
Phone: (770)918-6411
Fax: (706)557-3033
Click here to send e-mail

Section 2.4.2

V-476

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Home / Commercial Fishing / Landings and Licensing Statistics

Commercial Landings Data

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Commercial Seafood Landings data are collected via trip tickets completed by seafood harvesters and dealers. Several summaries of Georgia's landings are available as Adobe Acrobat (pdf) files. If you have trouble opening these files this may help.

- 10-Year Summary of Georgia landings by broad category
- Blue Crab (including peeler crab and softshell crab) data for the years 1989-2004
- Food shrimp pounds, value, and average price per pound 1973-2004

If you have detailed data needs please contact Julie Califf, Commercial Fisheries Statistics Coordinator.

Georgia landings data are also available from the National Marine Fisheries Service(NMFS) the Atlantic Coastal Cooperative Statistics Program (ACCSP).

The End

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Cited as "Georgia DNR 2005"

GDNR 2005

SUMMARY OF GEORGIA HISTORICAL LANDINGS BY BROAD CATEGORY

Georgia Department of Natural Resources, Coastal Resources Division One Conservation Way, Brunswick, GA 31520 (912) 264-7218 http://crd.dnr.state.ga.us

Year		Food Shrimp	Hard Blue Crabs	Bait Shrimp	Hard Clams	Pelagics	Offshore Demersals	Shad	Other Finfish	Misc. Crustacean & Mollusks	Whelks	Oysters	Total
1994	lbs	4,581,070	8,853,564	60,833	10,824	180,057	417,159	75,785	196,631	65,782	672,617	13,624	15,127,946
	value	19,783,714	4,510,691	562,552	73,158	122,826	655,338	80,945	163,725	211,057	377,323	29,764	26,571,093
1995	lbs	7,255,073	9,298,860	59,753	9,763	96,548	398,103	172,525	170,141	83,673	557,129	6,340	18,107,908
	value	27,002,973	5,020,608	572,736	64,974	78,981	698,915	131,350	163,436	257,288	336,654	15,571	34,343,486
1996	lbs	4,132,607	5,791,688	53,798	31,647	69,187	339,553	152,241	161,044	108,745	425,534	4,269	11,270,313
	value	16,335,208	3,018,151	519,561	194,409	35,166	576,617	109,285	152,500	368,962	254,717	9,227	21,573,803
1997	lbs	4,543,631	6,808,290	58,376	16,281	35,386	262,831	125,872	184,650	179,622	621,230	7,480	12,843,649
	value	22,254,286	3,835,798	590,563	114,521	32,290	443,529	93,540	174,552	532,564	389,437	18,428	28,479,507
1998	lbs	4,370,638	5,035,542	59,887	17,416	19,354	276,170	136,881	95,645	140,892	582,515	6,956	10,741,896
	value	19,080,321	2,603,991	634,375	122,891	18,189	502,850	86,370	88,690	490,948	406,942	17,212	24,052,778
1999	lbs	4,380,827	3,901,477	59,918	24,912	119,695	306,919	45,905	106,779	239,458	591,166	6,608	9,783,664
	value	18,364,973	2,045,645	665,633	153,074	71,030	607,009	45,496	103,670	469,301	415,000	17,325	22,958,156
2000	lbs	3,516,895	3,202,383	52,363	25,352	27,329	398,833	58,081	72,448	94,610	421,243	3,800	7,873,337
	value	17,205,600	2,077,436	565,352	212,821	28,285	791,729	33,490	72,298	399,445	277,482	9,733	21,673,670
2001	lbs	2,761,027	2,702,343	62,759	24,872	27,351	451,522	34,611	30,122	1,225,170	325,761	8,528	7,654,066
	value	10,459,975	2,500,704	576,569	186,644	23,516	869,233	27,729	30,714	496,320	245,330	22,254	15,438,987
2002	lbs	3,393,184	2,027,491	76,016	48,611	69,544	456,283	27,699	42,112	1,553,296	63,585	7,996	7,765,817
	value	11,126,124	1,967,968	688,185	319,412	43,742	851,528	22,682	42,519	440,057	49,621	19,997	15,571,835
2003	lbs	3,369,982	1,854,806	79,219	74,893	32,575	315,532	36,076	25,143	1,590,896	90,169	10,976	7,480,267
	value	9,299,556	1,901,227	723,316	520,515	20,925	572,774	27,024	28,709	400,204	69,393	31,019	13,594,662
2004	lbs	3,223,016	3,059,284	70,820	69,826	16,191	333,271	42,392	30,479	1,160,738	3,375	5,108	8,014,500
	value	10,123,143	2,313,188	635,351	426,048	16,984	665,328	34,285	33,448	429,375	3,693	14,859	14,695,702
2005	lbs	213,364	560,552	70,820	1,657	2,273	110,350	45,387	12,786	27,676	2,526	1,332	**1,048,723**
	value	667,937	554,235	635,351	2,264	2,307	218,738	43,873	12,730	77,410	2,526	3,974	**2,221,344**
Average	lbs	4,230,493	**4,947,644**	**62,292**	**28,457**	**67,703**	**362,291**	**86,568**	**108,472**	**528,214**	**435,095**	**7,658**	**10,864,886**
1994-2004	value	17,091,273	**2,948,222**	**609,884**	**196,242**	**47,495**	**656,952**	**65,791**	**102,081**	**406,615**	**282,190**	**19,053**	**22,425,798**

Values are ex-vessel

Shrimp weights are pounds of tails

Clam, oyster, whelk, and scallop values are pounds of meat.

Crab and fish are pounds of whole animals

updated 6/17/2005

2005 data are incomplete and subject to change

conversions available upon request

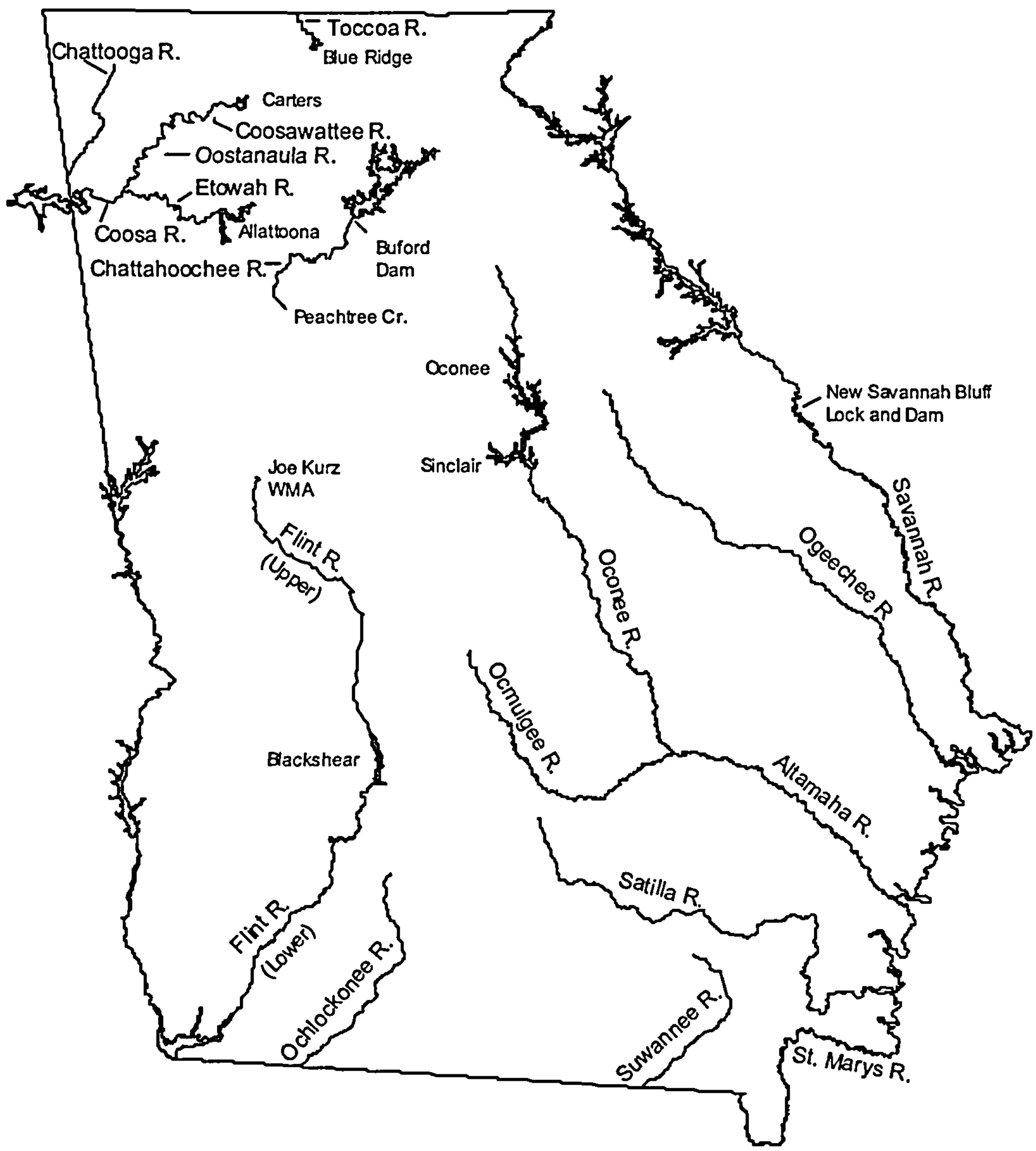
GDNR 2006 section 2.4.2

2006 Georgia River Fishing Prospects

V-475

"takemefishing"

A publication of the
Georgia Department of Natural Resources
Wildlife Resources Division
Fisheries Management Section



SPORT FISH RESTORATION

Your purchase of fishing equipment and motor boat fuels supports Sport Fish Restoration and boating access facilities

2006 Georgia River Fishing Prospects

There are over 12,000 miles of warmwater streams in Georgia. Following are the 2006 fishing prospects for the Altamaha, Chattahoochee, Chattooga (NW Georgia), Conosauga, Coosa, Coosawattee, Etowah, Flint, Ochlockonee, Ocmulgee, Oconee, Ogeechee, Oostanaula, Satilla, Savannah, St. Marys, Suwannee and Toccoa rivers. These prospects are based on sampling efforts conducted by the Georgia Department of Natural Resources, Wildlife Resources Division (WRD), Fisheries Management Section. Information collected allows Fisheries staff to determine recruitment, growth, condition, sizes, abundance and mortality of important game fishes. We hope this publication will prove useful in planning your fishing trips, as well as inform you about current issues and the status of the fish populations in these rivers. Sampling efforts and the development of this publication are funded through Sport Fish Restoration Funds.

WRD encourages anglers to participate in the Georgia Angler Award Program. All sport fish are eligible, but there are minimum weights your fish must meet or exceed. The fish must be legally caught on sport fishing tackle, weighed on scales certified accurate by the Georgia Department of Agriculture in the presence of two witnesses, and be verified to species by WRD Fisheries Management Section staff. Recipients will receive a certificate and an angler award cap embroidered with the year, fish species and weight. Check the WRD website at www.gofishgeorgia.com, the current Sport Fishing Regulations, or call a WRD Fisheries Management Section office to learn more about this and other WRD programs.

The Georgia Department of Natural Resources routinely tests the tissue of fish collected from rivers and reservoirs across the state. Based on the best scientific information and procedures available, "Guidelines for Eating Fish from Georgia Waters" are developed to help Georgia anglers and their families evaluate the health risks of eating fish from wild populations. To learn more about these guidelines consult the current Sport Fishing Regulations, or the EPD website at www.gaepd.org/Documents/fish_guide.html .

Visit the WRD web site at www.gofishgeorgia.com for fishing regulations, to locate a boat ramp in Georgia, to purchase a fishing license, to register a boat, to find a new place to fish and much more!

Fisheries Management Section Offices:

Albany......... 229-430-4256	West Point......... 706-845-4290	Social Circle.......... 770-918-6418
Burton......... 706-947-3112	Dawson......... 229-995-4486	Summerville.......... 706-857-3394
Calhoun....... 706-624-1161	Fort Valley......... 478-825-6151	Thomson............... 706-595-1619
Gainesville.. 770-535-5498	Richmond Hill......... 912-727-2112	Waycross 912-285-6094

Abbreviations: COE - U.S. Army Corps of Engineers; DNR - Georgia Department of Natural Resources; WRD - Georgia Wildlife Resources Division; USGS – U.S. Geologic Survey; TVA – Tennessee Valley Authority; USFS – U.S. Forest Service

Altamaha River

The Altamaha River is a popular destination for bass anglers. Over 30 largemouth bass tournaments are held yearly on this river. Comparing bass tournament results on Georgia waters for the last several years shows that the Altamaha River consistently has one of the highest average catch rates in the state. The relatively high water conditions that persisted throughout much of 2005 and early 2006 should lead to excellent bass fishing this year. High water conditions are beneficial to largemouth bass reproduction and growth. Therefore, anglers should land plenty of fat and sassy bass in 2006. Expect to catch mainly small-intermediate sized bass, around 10-16 inches, but be ready for an occasional lunker. Oxbow lakes and slack-water areas containing overhanging willows and woody structure are popular fishing locations, especially in the spring. Later in the summer, try fishing eddy pockets, the downstream end of sandbars, and heavy cover along the banks. Popular lures include crankbaits, spinnerbaits, plastic worms and lizards.

The Altamaha River is one of the premier flathead catfish rivers in the southeast. Many large flathead catfish are thriving in the river. Flatheads are an excellent fish to eat, and unlike channel catfish, the flesh of large flatheads maintains a high quality taste. The high water conditions that were present over the last few years caused a rebound in the numbers of flathead catfish in the Altamaha River. Annual samples conducted by WRD showed that the number of flatheads in the river had returned to the historical highs that were observed in the mid-90s. The average size of all the flathead catfish collected during these samples was just over 4 lbs. However, there were also many fish well over 30 lbs. collected during these samples. All of the fish collected during WRD's annual catfish population sampling on the Altamaha River were measured, weighed and released. Fishing for flatheads begins in early spring and peaks in the hot summer months when the river is well within its banks. The better fishing occurs in deep holes located along the outside bends in the river. An electronic fish finder is useful in locating deep holes and fish. If you are using sporting tackle, a minimum of 30-pound test line is recommended due to the numerous snags in the river and the flatheads' large size (30-50 lbs. fish are not uncommon!). Live bait is a must. Large worms (Louisiana pinks), shiners and bream are some of the more popular baits. Set lines or limb lines are also a popular and effective way to harvest flatheads. Most anglers fish limb lines or trot lines overnight using hand-sized bream as bait. Since flatheads are more active at night, depth is not as critical with these gear types. For more information on flathead catfish and fishing tips, obtain a free copy of the "Flathead Catfish Fishing Guide" from a Fisheries Section office. Flatheads are prevalent throughout the river, but the highest densities of flatheads are found between Jaycees Landing (river mile 67) and

Altamaha Park (river mile 30).

The crappie population has remained relatively stable over the past several years so angler success will be similar to 2005. The oxbow lakes that lie between US Hwy. 84 and the Seaboard Railroad offer some of the better crappie fishing opportunities.

Historically, the Altamaha River has been known for its outstanding bream fishery. This winter the Altamaha has remained relatively high providing favorable conditions for over-winter growth, which should enhance the numbers of quality redbreast present in 2006. Deep holes with cover along the main river channel are some of the more productive fishing areas for this species. Redbreast can be caught using both live bait and artificial lures. Some of the more popular live bait tactics are fishing crickets and worms under bobbers or fishing them on the bottom with split-shot weights. Small beetle spins, rooster tails and popping bugs (on a fly rod) are effective artificial lures for enticing redbreast sunfish to strike.

Due to the high water levels that persisted throughout much of 2005, anglers should reel in plenty of quality bluegill and shellcracker bluegill in 2006. Fall electrofishing samples revealed some of the highest abundances of these species present in the last 10 years. Try fishing for these two species in the still-water (oxbow) lakes off the main river channel. Bluegill and redear fishing picks up in late April when they begin bedding and continues throughout the summer. Overall, it should be another good year for bream fishing with an abundance of quality-sized fish. Bluegill and redear sunfish can be harvested using the same methods as described for redbreast sunfish, but slower moving water is typically more productive.

A guide to fishing the Altamaha River is available. It contains a map, access sites and helpful fishing tips. Call a Fisheries office for a free copy.

Chattahoochee River (Buford Dam to Peachtree Creek)

Many people are unaware that in addition to supplying nearly 70 percent of metro-Atlanta's drinking water, the 48-mile stretch of the Chattahoochee River downstream of Buford Dam contains a world-class fishery for both brown and rainbow trout. The current state record brown trout weighing an impressive 18 lbs. 6 oz. was caught from the Chattahoochee! The river is heavily stocked with hatchery raised nine-inch rainbow trout. More than 38 percent of the brown trout and approximately 3 percent of the rainbow trout are wild fish spawned in the river. In addition to offering some of the best trout fishing in North Georgia, the Chattahoochee also supports numerous other fish species including yellow perch, shoal bass, largemouth bass, chain pickerel, bream, catfish, crappie and striped bass.

Trout water begins at the base of Buford Dam where cold, clear water flows from the bottom of Lake Lanier. Buford Dam is a peaking hydropower facility, which means it can release water at any time. Water levels can fluctuate as much as 4-8 feet, so before you start any fishing trip call 770-945-1466 or visit http://water.sam.usace.army.mil for information on the water release schedule at Buford Dam. Call 404-329-1455 for the water release schedule at Morgan Falls Dam. Since the upper section is subject to the rapid rise of water, a personal flotation device must be worn at all times from Buford Dam to Georgia 20. Trout waters can be broken down into two distinct reaches:

Buford Dam to Roswell Road (Hwy 9): Water temperatures are normally 50-65 °F year round, so anglers should plan to wear insulated waders to protect against hypothermia. There are 19 county and federally maintained public access points offering bank access, wading and boating opportunities. Boaters should be cautioned that the river is relatively shallow and rocky during low flow conditions and passage upstream to Buford Dam is limited to shallow drafting boats with jet motors. There is an artificial lures only section from the Georgia 20 bridge downstream to the National Park Service Medlock Bridge Park boat ramp. An artificial lure is defined as any lure that is either man-made or made of a natural substance (such as wood or cork), which is not scented or which does not contain chemical attractants. River conditions, water flow, and water clarity affect fishing success on the river. Fish the river during clear, low flows for best success. The river can become muddy after rains, which can reduce fishing success. However, bait fishing and spin and fly anglers using in-line spinners can be successful in turbid water. .

For fly-fishing, 8½ to 9-foot rods for 5 to 6 weight/forward floating and/or sinking tip lines are recommended. Small nymphs and flies work well. Popular flies for this area include a No.10 or No.12 brown or black bead-head wooly bugger or a No.14 bead-head Prince Nymph. When trout aren't responding, try a dropper rig with flies like a No.16 Elk Hare Caddis with a No.14 bead-head Prince Nymph as the dropper. Cast upstream across the current in runs for rainbows and near logs and overhangs for browns. Five-to-seven feet long rods, with 4 to 6 lbs test line, are ideal for spin fishing. Consider using 1/8 oz Rooster Tails in brown, green or yellow. Panther Martin 1/8 oz spinners in yellow or orange are also popular, as are size 3-5 inch Rapalas with perch, rainbow trout, gold or silver patterns.

Brown trout have successfully reproduced in this section since the late 1990s. WRD ceased stocking brown trout in 2005 to determine the real potential of a river spawned wild brown trout population in the river. Brown trout will not be stocked for a 3-5 year period. WRD will continue to annually stock 150,000 trout, but they will be all rainbows. WRD will closely monitor the brown trout population to determine if stocking is needed to maintain a quality brown trout fishery. So chances are that the next brown trout you catch will be a wild, river-spawned fish!

Morgan Falls Dam to Peachtree Creek: The habitat in these 12 miles of river is much wider and shallower than the reach below Buford Dam. As a result, water levels do not fluctuate as much. Storm flows can still make this reach unwadeable at times, so plan on calling 404-329-1455 for river conditions before going fishing. This reach was once considered a world-class trout fishery, but several factors including increased impervious surfaces (roads, parking lots, roofs) in the watershed, siltation and changes in releases from Buford Dam have caused water temperatures to rise above that acceptable for trout. The number of trout that survive in the river declines during the warm weather months (May through October). However, trout do survive the warm water periods so don't cross the river off your list! Fishing the Delayed Harvest (DH) section from Sope Creek (off Columns Drive) downstream to US Hwy 41 has become very popular with anglers. WRD stocks 50,000 rainbow and brown trout during the DH period and large trout up to 22 inches are part of the mix. Word of anglers catching over 70 trout in 2-4 hours are not unheard of! Anglers must release all trout immediately and use and possess only artificial lures with single hooks from November 1 through May 14 annually. Anglers can keep trout and use natural bait from May 15 through October 31. Anglers fishing for species other than trout must abide by the artificial lure only regulation while fishing in the DH section.

For fly-fishing, consider a Parachute Adams in a No.18-22. A black or olive wooly bugger seems to work well when fish are picky. Bead Head Prince, Hares Ear and Pheasant Tail flies in No.14-18 also work well. During an insect hatch, a small Blue Wing Olive or Griffiths Gnat in a No.18-22 may be a better choice. Winter fishing in the river upstream of the DH section between Morgan Falls Dam and Sope Creek can be very productive for yellow perch, shoal bass, largemouth bass, chain pickerel and striped bass. The days to target for best success are sunny days with low, clear water at 45-55 °F.

Look for blowdown trees in the sun with a deep hole on the downstream side. Cast minnows or worms in the hole with a drop-shot rig and wait. Let the fish take the bait then start reeling. Use extra tough line as chain pickerel up to 28 inches have been caught!

WRD initiated a project in 2003 to restore the shoal bass population downstream of Morgan Falls Dam. Shoal bass are native to the Chattahoochee and the extensive shoal habitat downstream of Morgan Falls Dam likely sustained a healthy population prior to construction of Buford Dam in 1958. A small population of shoal bass still exists in this section. A five-year stocking program began in 2003 with the stocking of shoal bass fingerlings. Shoal bass fingerlings were stocked in 2003, 2004 and 2005. Survival and growth of these fish will be monitored over the next five years to assess the success of these stockings. The goal is to restore this native fish to historical population levels, which will provide additional sport fishing to Metro-Atlanta anglers. Shoal bass numbers are already increasing, some larger than 3 lbs. These fish are challenging and exciting on both fly-fishing and spin fishing gear. Keep your eyes on this developing fishery!

Large striped bass in the 15-25 lbs. range are found in this section year-round, especially during the summer months. Striped bass numbers are likely to increase as West Point reservoir is now being stocked with striped bass again. Striped bass migrate out of West Point in search of cooler water during the summer, which the Chattahoochee has plenty of. Not many anglers are targeting stripers here, so this is relatively uncharted territory! There are largemouth bass, chain pickerel, black crappie, yellow perch, spotted bass, bluegill and redear sunfish (shellcracker) in the slower moving stretches all along the river.

The National Park Service (NPS) has started the process of developing the General Management Plan that will guide the management of Chattahoochee River National Recreation Area (CRNRA) over the next 15-20 years. Anyone interested in the future management of the CRNRA should visit the NPS website at http://parkplanning.nps.gov/projectHome.cfm?projectId=11174 and provide comments when the revised GMP is out for review. Printed maps of the CRNRA are available by calling the National Park Service (678-538-1200) or WRD (770-918-6418). A downloadable version is available online at the CRNRA Web site (http://www.nps.gov?chat/fishing.htm).

Chattooga River (Chattooga County)

The Chattooga River is a tributary of Weiss Reservoir. It originates just south of the City of Lafayette and meanders approximately 51 miles southwest through Walker and Chattooga Counties, Georgia. A narrow river channel with numerous navigational hazards makes most of the Chattooga River floatable only by canoe or small boat. Access to the river is limited to bridge crossings and an undeveloped ramp in Gaylesville, Alabama. Larger prop and/or jet boats can navigate the lower portion of the river below state Hwy. 27, but extreme caution should be exercised. The upper portion of the river is wadeable to anglers at bridge crossings and to those gaining landowner permission on private holdings.

Bream dominate the Chattooga River fishery. Bluegill, redbreast and redear sunfish call the entire length of the Chattooga River home. Redbreast are more abundant in the upper reaches of the river, while bluegill dominate the lower river reaches. Bream 5-8 inches are common with some slabs topping 10 inches in length. These larger bream are most common in the river above the city of Trion. Low fishing pressure has likely contributed to an abundance of these larger sunfish. Skilled anglers will target deep pools, log-jams, and undercut banks in search of these pan fryers. During the early summer these fish will bed in slack areas along the shore, behind debris and on the downstream side of sandbars. When it comes to artificial baits, small is the key. Small spinners and natural crawfish imitations, along with crickets and worms all will produce fish.

In contrast to the bream fishery, the Chattooga River black bass fishery is relatively poor. Redeye, largemouth and spotted bass can be found throughout the river, with redeye being more common in the upper reaches of the system. Spotted bass are the most dominate black bass species in the lower portion of the river. Largemouth are present, but are much less common. Most bass will be small and generally well under a pound in size. The largest individuals will be captured nearest to where the river enters Lake Weiss.

A modest catfish population can be found in the Chattooga River. Flatheads and blues are present, but they are greatly outnumbered by channel catfish. Channel cats are generally under a pound with few fish tipping the scales at two pounds. These speckled cats are most often located in moderately deep flowing habitats, especially those found in the outside river bends.

With the approach of spring, white bass will migrate into the lower Chattooga River. Spawning runs will peak in March and April as fish stack up around creek mouths in the river. White bass fisherman will likely find most of these spawn-run fish in the lower sections of the river below the Lyerly Dam area. The white bass bite will slow into May and become non-existent as the fish return to Weiss Reservoir with the approach of summer. Small jigs and crankbaits are favored lure choices for these "mini-linesides".

Like the white bass, the larger striped bass move into the Chattooga River during the spring months. However, unlike the white bass, stripers stay the summer searching for cool water refuges from which to spend the summer. Linesides from 1-25 lbs. can be caught in the Chattooga River, though the average fish will near 6-7 lbs. Live gizzard shad or cut bait are an angler's best bet, but aggressive stripers will hit shad imitations and top water plugs under the right conditions. More important than bait choice is fishing the right locality. Stripers congregate in large numbers in spring fed pools, especially around tree canopies and logjams and in the mouths of cool water tributaries. Flowing water near cover is key to catching one of these skinny water monsters.

Carp, drum, suckers and a number of redhorse species can be found in the river. Freshwater drum average slightly better than 12 inches in length, and a fair number of larger (17+ inches) "humpbacks" are present. The largest drum are concentrated in the "runs" of the river. These runs are generally 2-3 feet in depth at normal flows and can be characterized as having relatively swift flows. Runs along undercut banks and fallen trees are ideal places to catch drum. Small jigs fished along the bottom, crayfish, cut mussels, and shrimp are all good bets for boating these unique, but common, river resident.

Conasauga River

From its confluence with the Coosawattee River, upstream to its origin deep within the Cohutta Wilderness area of Fannin Co., the Conasauga River extends approximately 95 miles through rural north Georgia and a small portion of southern Tennessee. The river offers anglers a diverse fishing opportunity from wade fishing for trout in its upper reaches to boat fishing for catfish on its lower extent. Public boat access is restricted to a few road crossings and private boat ramps found over the course of the river. Boaters should use extreme caution navigating anywhere on the river as shoals, rocks and debris jams are common. A guide to fishing the Conasauga River is available in PDF (645 kB) format at www.gofishgeorgia.com. This document contains access and fishing tip information and a color map with river-mile designations.

The Conasauga River within the Cohutta Wilderness offers excellent fishing for both redeye bass and three trout species. Reaches downstream of the confluence with Rough Creek are generally considered the transition zone between redeye bass and trout fishing. Rainbow and brown trout generally range from 6-14 inches with "bruiser browns" occasionally topping 22 inches. Native brook trout up to 8 inches are found in the Conasauga headwaters and several smaller tributaries at elevations typically above 2,500 ft. Suggested fishing methods include matching the hatch for fly anglers, or offerings of worms or small spinners. The Conasauga and its tributaries (except the Jacks River watershed) upstream of the Georgia-Tennessee state line are restricted to using only artificial lures from November 1st through the last Saturday of March. The Jacks River watershed is only open during the regular trout season and natural baits may be used. A Cohutta Wilderness Area map is available from the US Forest Service for a nominal fee.

Three catfish species lurk the waters of the Conasauga River. Blue and channel cats make up the bulk of whiskered fish in the river while fair numbers of moderately sized flatheads round out the group. Blue cats average 20 inches, but anglers should focus their efforts for them in the lower section of the river below Hwy. 76. Channel cats are smaller than blues and typically measure in around 14 inches. They can be caught from the Tennessee state line downstream to Calhoun. The average flathead is around 20 inches with some hogs topping 30 inches and 20-30 lbs. in size. Like blues, fish for flatheads downstream of Hwy. 76 using live fish to coax strikes from the bigger individuals.

Bream fishermen have the opportunity to catch seven different sunfish species on the Conasauga River. Generally anglers will fish for the larger bluegill, redear and redbreast sunfish. Bream will be 5+ inches with some larger 8-9 inch fish available. Bluegill and redear are found throughout the river below the Tennessee state line. Redbreast sunfish favor the skinny water upstream of Hwy. 76. Live bait and small jigs fished around the pools of the river near fallen trees should produce bream of all kinds.

Bass fishing would be considered only fair on the Conasauga River. Spotted, largemouth and redeye bass hunt the entire river, but spotted bass definitely have a lease on most of it. Spots will strike just about anywhere on the river, but fish over 3 lbs. should be considered a good catch.

Freshwater drum, smallmouth buffalo, carp and variety of suckers are very common in the river. Freshwater drum are likely the most abundant large fish in the river and their numbers rival those of any river in Northwest Georgia. Drum are silvery grey and have a pronounced humped back. They average 12 inches in length, with "bull" drum commonly topping the 20-inch mark. Small jigs, live crawfish, cut mussels and shrimp fished on the bottom will entice a drum strike. Once hooked, these powerful bottom dwellers will generate excitement as they turn their wide bodies into the river current.

Lake sturgeon, once a resident of the Coosa River system (which includes the Conasauga River), disappeared in the 1960s. Pollution and over-fishing are believed to have eliminated these archaic fishes from the river system. Thankfully since then, water conditions have improved in the river and WRD has begun to re-stock lake sturgeon in an effort to reestablish this native fish. Since their first stocking in 2002 more than 41,000 sturgeon fingerlings have been released in the Coosa basin. This long-term reintroduction project will require annual stockings over the next 15 to 20 years to re-establish this native fish. Sturgeon grow slowly and do not mature for 12-15 years. Therefore, it is important to protect them from harvest until they can reproduce and once again support some limited harvest. Anglers accidentally catching a lake sturgeon should immediately release the fish unharmed. Fish hooked deep will often survive if anglers cut the line near the hook and release the fish with the hook. If you catch or see a sturgeon, please contact one of the following Georgia WRD offices to report the location {(706) 624-1161 or (706) 857-3394}. Such "sightings" are extremely helpful to biologists trying to assess the survival and dispersal of these magnificent fish.

Coosa River

The Coosa River flows 30.4 miles west-southwest from Rome, Georgia entering Lake Weiss at the Alabama state line. Four concrete boat ramps on the river offer boaters easy access to the upper, middle and lower portions of the river. The river is navigable by prop-boat over most of its length, though care is needed, as floating debris is commonplace on the river. The historical Mayo Lock and Dam, located approximately 7.1 miles downstream from Rome, is impassable to all but canoeists. A "*Guide to Fishing the Coosa River*" in PDF (645 kB) format contains access and fishing tip information, as well as a color map with river-mile designations. This downloadable, print quality document is available on the WRD website at www.gofishgeorgia.com, select "Fishing," then "Lake, Reservoir, River, Public Fishing Area Items," then "Georgia River Fishing Information" and "Coosa River."

From late February through early April, white bass pile-up in the Coosa River as they make their annual spawning run from Lake Weiss. Numbers will be down this year as past years spawning success has been down due to persistent drought conditions. The river section between the River Road boat ramp near Coosa, upstream to the Mayo Lock and Dam Park is "prime A" territory for catching spawn run white bass. Males will typically be ¾ lb. and show up on the spawning ground first, while egg laden females in the 1-2 lbs. range show up later in the season. Key in on creek mouths and fallen trees with good water flow around them in the main river. Hungry white bass congregate in these areas waiting on food to pass by on the current. Anglers targeting white bass should try casting small jigs and crankbaits in shad patterns or use live bait. Most likely, anglers will catch a mixed bag of white bass and crappie using these techniques.

The Coosa River is home to one of only a handful of naturally reproducing land-locked striped bass populations in the world. The average Coosa striper is 5-6 lbs., but linesides exceeding 30 lbs. are often caught during the spring spawning run in the area from the Mayo Lock and Dam upriver to Rome. Live or cut shad is the most popular bait, but a few stripers are fooled using artificial lures such as bucktail jigs, shad colored crankbaits and large jerkbaits fished in swift water near fallen trees. After the spawn, stripers disperse all over the Coosa River basin in search of cool waters to beat the summer heat. These fish can be found hiding wherever there is cool water in the rivers and smaller tributaries of the Coosa River. Find one of these spots and striped bass could be on the menu all summer. When cooler fall temperatures arrive, stripers will begin moving back toward the main lake where anglers can find them chasing shad on the main river. From mid to late winter the lower sections of the Coosa River into Lake Weiss are good bets to find some winter striper action.

Largemouth bass predominate, but spotted bass up to 4 lbs. occur in fair numbers around the main river's bluff banks and creek mouths. To take advantage of an excellent largemouth bass fishery, anglers must move into the sloughs and backwaters off the main stem of the Coosa River. Areas like Brushy Branch (Big Cedar Creek), Kings Creek and Mt. Hope Creek hold plenty of largemouth, but these stump-laden waters must be boated with care. The average "bucketmouth" will weigh 1-2 lbs., with larger individuals topping the

7-8 lbs. range.

Blue, channel and flathead catfish of all sizes are abundant. The larger blue catfish can top 50 lbs. Fish for these whiskered behemoths in and around log jams common along the river. Cats can be taken with a number of unsavory baits, but anglers should keep in mind most "trophy" cats are after live prey such as shad or bream.

Freshwater drum, smallmouth buffalo, gar and suckers are abundant in the Coosa. The average drum is slightly over 12 inches, but be prepared to hook into some bull drum over 20 inches in length. Bluegill, redbreast sunfish and redear sunfish, round out the fishing opportunity in the Coosa River.

A few anglers may encounter an odd-looking fish they have never seen before in the Coosa River or its tributaries. The lake sturgeon, once a resident of the Coosa River system, disappeared in the 1960s. Pollution and over-fishing are believed to have eliminated these archaic fishes from the river system. Thankfully since then, water conditions have improved in the river and WRD has begun to re-stock lake sturgeon in an effort to reestablish this native fish. Since their first stocking in 2002 more than 41,000 sturgeon fingerlings have been released in the Coosa basin. This long-term reintroduction project will require annual stockings over the next 15 to 20 years to re-establish this native fish. The species grows slowly and does not mature for 12-15 years so it is important to protect them from harvest until they can reproduce and once again support some limited harvest. Anglers accidentally catching a lake sturgeon should immediately release the fish unharmed. Fish hooked deep will often survive if anglers cut the line near the hook and release the fish with the hook. If you catch a sturgeon, please contact one of the following Georgia WRD offices to report the location from which the sturgeon was caught {(706) 624-1161 or (706) 857-3394). Such "sightings" are very helpful to biologists trying to assess the survival and dispersal of these magnificent fish. Those wondering what impact sturgeon will have on their favorite game species can rest easy. Because of its low reproductive potential, the fish does not establish itself as a prominent species making its impacts negligible. In fact, the species poor reproductive potential has caused the species to be listed as rare or endangered throughout most of its original range.

Coosawattee River (Below Carters Dam)

The lower Coosawattee River extends approximately 25 miles from Carters Reservoir to its confluence with the Conasauga River northeast of Calhoun, Georgia. Public boat access is limited, but anglers prepared for an all day outing can float from the small boat access at Carters dam to the only public ramp at Hwy. 225 near Calhoun in a solid day's time. A "*Guide to Fishing the Coosawattee River*" in PDF (666 kB) format is available on the WRD website at www.gofishgeorgia.com, select "Fishing," then "Lake, Reservoir, River, Public Fishing Area Items," then "Georgia River Fishing Information" and "Coosawattee River." The document contains access and fishing tip information, as well as a color map with river-mile designations. Navigation is relatively easy for small boats over the entire river, but care must be given to avoid several shallow shoals and tree-falls in the river. In addition, water levels can change abruptly during periods of water release at Carters dam. Daily generation schedules for the dam can be obtained by contacting the COE at Carters Reservoir (706-334-2248).

Catfish are extremely abundant in the waters of the lower Coosawattee River. Channel and blue cats dominate, with flatheads being far less common, and generally found in the extreme lower portion of the river near Calhoun. Channels and blues are found throughout the river, however blue cat numbers tend to increase going downstream. Anglers tossing chicken liver and cut bait below shoals, undercut banks, and log-jams will produce fish, but most "bragging cats" will hold out for live offerings such as bream or shad. The average channel cat will run about ½ lb., while the average blue will near 1¼ lbs. These "deep fryers" are numerous and anglers are encouraged to harvest fish in this size range. Harvesting average size fish will help improve growth rates of those remaining, resulting in larger cats for the future.

A number of bream species call the Coosawattee home, but bluegill and redbreasts by far have a lease on most of it. Both are found in good numbers throughout the river, but they are most abundant in the three-mile river stretch below Carters dam. The average fish will be 5-6 inches, but plenty of 7-9 inch fish are swimming these waters. Crickets, worms and small artificials, fished in areas of deep slack water behind river obstacles, root wads, and tree-falls are all potential hangouts for these species.

Three species of black bass patrol the Coosawattee River, with spotted bass dominating more than 50 percent of the group, followed by redeye and largemouth bass. The spot fishery is better than most large rivers in the immediate area, affording anglers the opportunity to catch a fair number of spots in an outing. Coupled with good numbers, spotted bass up to 6 lbs may stretch lines in and around the numerous log-jams and deep pools found in the river. Redeye bass are smaller than spots, but what they lack in size they more than account for in aggressiveness and power. Most redeye will be under a pound, which is typical for the species. However, anglers hooking into large redeye with light spinning tackle will have their hands full. Largemouth are generally rare in the river as would be expected given habitat more suited for the previously discussed bass species. Nevertheless, a few "bucket-mouths" can nicely round out an angler's day on the water.

Striped bass inhabit the Coosawattee River, especially during the summer and early fall months when they are seeking cool water to beat the summer heat. Stripers will generally range in size from 1 - 25 lbs., with the average lineside tipping scales in the 5-6 lbs. range. Most striper fishing is done in the river below Carters dam, however fish can be found in deep holes or in the mouths of feeder creeks throughout the river. Since striped bass feed heavily on shad, live or cut shad is key, though artificials have their place on the river.

The Coosawattee is once again home to a sportfish species that disappeared from the river nearly 40 years ago. Since 2002, 41,000 plus lake sturgeon have been re-introduced to the Coosawattee and surrounding rivers in the greater Coosa River basin. Pollution and overfishing are believed to have eliminated most of these archaic fishes from the river system in the 1960's. Thankfully since then, water conditions have improved in the river. Through long-term annual stocking it is hoped the species will reclaim much of its historic inhabitance within the river. The species grows slowly and does not mature for 12-15 years so it is important to protect them from harvest until they can reproduce and once again support some angler harvest. Anglers accidentally catching a lake sturgeon should immediately release the fish unharmed. Fish hooked deep will often survive if anglers will cut the line near the hook and release the fish with the hook. If you catch a sturgeon, please contact the Calhoun (ph# 706-624-1161) or Summerville (ph# 706-857-3394) WRD offices to report the location from which the sturgeon was caught. Such "sightings" help biologists assess the status of these magnificent fish.

Rounding out the Coosawattee fishing experience is a host of often overlooked fish species - suckers, redhorse, carp and freshwater drum are found throughout the river in large numbers. In fact, freshwater drum is one of the most abundant fish species found in the river. These silver, hump-backed fish range in size from just a few inches to over 20 inches in length, though the average drum will run

11 inches. While abundant throughout the river, the few hundred-yard stretch below Carters dam is a hot bed for drum. The species prefers moderately deep flowing river sections in which to feed. Small jigs bumped along these areas, live crawfish, cut mussels, worms, and shrimp fished on the bottom are an angler's best approach to drumming up one of these unique fishes.

Lower Etowah River (Below Allatoona Reservoir)

Extending nearly 49 miles from the Lake Allatoona Dam downstream to Rome, Georgia, is the lower Etowah River. Water flow in the Etowah is greatly influenced by water releases from Allatoona Dam. During dam operation the waters of the Etowah can rise as much as 3-4 feet in a short period, creating sometimes dangerous boating conditions. The water release schedule is variable, but the weekly generating schedule can be obtained from the United States Army Corp of Engineers at (678) 721-6700. For the most part, public access is limited to portages at bridge crossings, but the lower stretch of river is boat accessible from the concrete ramp at Heritage Park in Rome. A "*Guide to Fishing the Etowah River*" is available on the WRD website at www.gofishgeorgia.com, select "Fishing," then "Lake, Reservoir, River, Public Fishing Area Items," then "Georgia River Fishing Information" and "Etwoah River." The document contains access and fishing tip information, as well as color map with river-mile designations. Boaters should use extreme caution as fluctuating water levels and rocky shoals throughout the river make navigation a challenge.

Bluegill, redbreast and redear sunfish dominate the Etowah River bream fishery. The average fish approaches 6 inches with nicer fish in the 7-8 inch range being present. Sunfish numbers are greatest in the river above state Hwy. 411. Fallen trees and log-jams are the key if anglers want to catch these species in numbers. Small jigs and spinners will work, but live bait is probably an angler's best approach for catching "dinner" numbers of these fish.

Do not overlook the "whiskered" resources of the lower Etowah River. Catfish likely offer anglers one of the best angling opportunities in the area. Channels, blues and flatheads all call the Etowah home. Channel catfish are more abundant than blues and flatheads, but what the blue cat lacks in numbers it more than makes up for in size. The average blue tips the scales at nearly 3 lbs., with 8-10 lbs. being commonplace. More excitingly, blue cats over 40 lbs. in size are caught every year from the lower Etowah. These aren't your typical chicken liver cats. Though this approach will boat catfish, the trophy individuals will hold out for offerings of live or cut shad. Hunt these behemoths in the Etowah's deep flowing pools, especially those associated with some type structure.

Striped bass are the lower Etowah's crown jewel for fisherman. Stripers move into the Etowah in April and reside there through October. The average fish will be 6-7 lbs. with "pole-benders" approaching 30 lbs. lurking the depths. These fish congregate in the numerous coldwater refuges the Etowah offers during the summer heat. Good concentrations of stripers can be found in the river above and below state Hwy. 411. Stripers are best fished from a small boat, as public access is limited. Live bait is key, though artificials have their place on the river. Anglers throwing surface lures at dawn and dusk just may be rewarded with some awe inspiring surface strikes from these powerful fish.

Three black bass species can be found over the length of the Etowah, though spotted bass comprise approximately 81 percent of the black bass population. Largemouth and redeye bass make up the difference. Overall the black bass population would be characterized as "fair". The bulk of the population is made up of fish less than 12 inches, however spots to 20 inches can be found. The largest spots are often boated using live bait fished in deep water. Work baits near cover, especially cover associated with deep flowing water. This approach may also land the occasional striper.

Smallmouth buffalo, freshwater drum and several sucker and redhorse species can be found in the Etowah. Buffalo and drum are two of the most abundant fish species residing in the river. Anglers do not often pursue freshwater drum, nevertheless these hard fighters offer a unique angling opportunity. Atop large numbers of 12-inch fish, the Etowah produces some extremely large "humpbacks". Drum over 20 inches can be found in the best river habitats. These bottom feeders will concentrate in the runs of the river. Water 2-3 foot deep moving at a good clip will hold the greatest number and largest drum. Small jigs bumped along these areas, live crawfish, cut mussels, and shrimp fished on the bottom will entice a strike. Some of the best drum water can be found in the mile or two stretch of river above Hwy. 1 (Rome Loop) in Rome.

The Etowah is once again home to a sportfish species that disappeared from the river nearly 40 years ago. Since 2002, 41,000 plus lake sturgeon have been re-introduced to the Etowah River and other rivers in the greater Coosa River basin. Pollution and overfishing are believed to have eliminated most of these archaic fishes from the river system in the 1960's. Thankfully since then, water conditions have improved in the river. Through long-term annual stocking it is hoped the species will reclaim much of its historic inhabitance within the river. The species grows slowly and does not mature for 12-15 years so it is important to protect them from harvest until they can reproduce and once again support some angler harvest. Anglers accidentally catching a lake sturgeon should immediately release the fish unharmed. Fish hooked deep will often survive if anglers will cut the line near the hook and release the fish with the hook. If you catch a sturgeon, please contact the Calhoun (ph# 706-624-1161) or Summerville (ph# 706-857-3394) WRD offices to report the location from which the sturgeon was caught. Such "sightings" help biologists assess the survival of these magnificent fish.

Flint River (upper)

The upper Flint River is one of Georgia's most treasured natural resources and home to a unique and productive sport fishery. The scenic qualities of the Flint River provide an opportunity to combine fishing with an experience of natural beauty that few rivers in the southeast can surpass, and all only a short drive from Atlanta, Macon or Columbus. The upper sections are especially suitable to the canoe and kayak float trips that are increasingly popular with all age groups. Although it is fair to say that the upper Flint River has been "discovered," at times of the year you can still have this river almost to yourself.

The Flint River originates near the bustle of Hartsfield-Jackson International Airport, but the noise rapidly subsides as the stream winds south, passing west of Griffin before flowing along the eastern edge of Joe Kurz Wildlife Management Area (WMA). Conditions permitting, the river is navigable by canoe as far north as Woolsey, but the section between Joe Kurz WMA and Atlanta receives little fishing pressure due to limited access, shallow water and obstructions such as fallen trees and a low head dam just below Hwy. 92. Within this section, those with access and determination may be rewarded with some good redbreast fishing and the occasional shoal bass or largemouth bass.

From the first major public access at Joe Kurz WMA, the river flows 27 river miles through a series of major rapids and shoals interspersed with slow moving flatwater sections, and even past "mountains" up to 1,200 feet before reaching Sprewell Bluff State Park. From Sprewell Bluff the river's untamed and scenic character continues for another 37 river miles, passing Big Lazer Creek WMA before crossing the Fall Line in the vicinity of Hwy. 128 (near Roberta). At this point the river becomes a sandy, meandering stream with only occasional rock outcrops. It continues for another 63 river miles before entering Lake Blackshear, the first of three impoundments along the river's length.

The entire 128-river mile reach of the Flint River from Joe Kurz WMA to Lake Blackshear provides excellent fishing, but many anglers prefer the upper Piedmont section from Joe Kurz WMA to around Hwy. 128, because of its scenic qualities and numerous shoals. A favorite technique involves floating or motoring to a major shoal and then wade-fishing the pools and swift runs with spinning tackle or fly rod. These shoals are the favored habitat of the aptly named shoal bass and this is by far the most popular species among Flint River anglers. Local names for notable fishing shoals include Waddell, Dripping Rock, Goat Mountain, Pasley, Sprewell Bluff, Owens, Yellow Jacket, Hightower, Daniels and Snipes. Although most of these shoals are easily navigated by canoe, occasional whitewater near the Class III level requires caution, especially in the area between Sprewell Bluff and Po Biddy Road. Major access points in the Piedmont section of the Flint River are at Joe Kurz WMA, Hwy. 18, Sprewell Bluff State Park, Hwy. 36, Po Biddy Road, Hwy. 80, and Hwy. 128. WRD has recently constructed new boat ramp facilities at Joe Kurz WMA and Hwy. 128.

Shoal bass are the signature species of the Flint River. They resemble smallmouth bass but are actually a completely unique species native only to the Flint and Chattahoochee rivers and their major tributaries, as well as in the Chipola and Apalachicola rivers of northwest Florida. They were stocked into the Ocmulgee River in the 1980s. Shoal bass can reach weights of over eight pounds and are an exciting challenge in the swift water. Preferred spinning gear is in the light to medium category since many shoal bass caught in the Piedmont section of the Flint River will be in the 11 – 13 inch range, but you should always be prepared for the 17 - 20 inch tackle buster. A shoal bass weighing 7 lbs. 5 oz. was caught in the Flint River in 2004.

Shoal bass can be caught on a wide variety of lures, and some of the favorites are small swimming minnows, spinner baits, top water poppers and Texas-rigged worms and lizards. Wading the shoals is particularly suited to fly-fishing. Just bring your six to eight weight bass or trout rod and plenty of wooly buggers and poppers. A bronze flash will often follow a cast into the clear runs and pools as a shoal bass strikes your lure or fly. All serious Georgia anglers should experience this truly unique fishery.

Shoal bass were abundant in recent WRD samples from the Piedmont section of the upper Flint River, with the highest density in the area between Hwy. 18 and Sprewell Bluff State Park. Larger fish in the 14 – 20 inch range were especially abundant, comprising about 30 percent of the sample. A similar percentage was in the 11 - 13 inch range. Good reproductive and recruitment success was apparent in the large numbers of fish in the 5 – 10 inch class and this should produce some quality fishing during the next several years. Although you can catch shoal bass in the Flint River year-round, the best months are May and June followed by the September through November period. On a good day you can expect to catch over 20 shoal bass. Please remember that Flint River shoal bass less than 12 inches must be released and the practice of catch and release is generally encouraged.

Shoal bass may win the popularity contest, but redbreast sunfish remain the favorite of many. These colorful little fighters are fun to catch on ultra light gear and are excellent eating. Since they are found in the same areas as shoal bass it is easy to target both species on the same trip. In addition to the shoals, redbreast are also found along the banks around snags in moderate to slack current. Favorite lures are very small spinners such as roostertails, small curly-tail grubs with spinners, beetle spins, and the smallest crank baits. Crickets may at times produce better than artificial lures. Fly fishermen should bring small poppers and wet flies that resemble spiders or caterpillars. The Flint River is noted for its hand-size redbreast and this year you can expect about 30% of your redbreast catch to be in the 6-7 inch class. The present size distribution indicates good reproduction and if flows are suitable good redbreast fishing can be expected for at least the next couple of years.

Although seldom specifically targeted, largemouth bass, bluegill, shellcracker and crappie are common in the Piedmont section of the Flint River. These species are typically found in slack water areas and will rarely be caught in the shoals favored by shoal bass and redbreast. Fishing for these species requires a boat and the best method is drift fishing in slack water areas, casting deep into snags along the bank with the same tackle used for these species in lakes and ponds. The result can be a relaxing and often productive day of fishing.

Catfish round out the picture and both channel and flathead catfish are popular with Flint River anglers. Many catfish anglers use set hooks or trotlines, but both species can be caught with rod and reel as well. Channel catfish are most abundant in deeper areas around shoals and in deeper river bends, particularly near snags. Preferred baits are earthworms, prepared baits, liver, catalpa worms, and crayfish. Flathead catfish are abundant in the Piedmont, but are generally smaller than in Coastal Plain areas below Hwy. 128. Regardless of location or method, you must use live bait to catch flatheads. Most flathead fishermen use live bream, but large minnows, shad or even small catfish will also produce. Flatheads are always most abundant in deeper river bends around snags, and patience is required since they seem to feed actively for only short periods during the day. Flathead catfish can reach over 40 lbs. in the Flint River and stout gear is required to keep the powerful fish out of the snags where they hide and ambush their prey.

The character of the Flint River is altered dramatically after it passes over the Fall Line in the vicinity of Hwy. 128. Bottom substrate changes from the diverse mixture of sand, bedrock, boulders, gravel, and cobble of the Piedmont to predominantly sand with only occasional boulders and gravel deposits. The river channel also begins to meander creating the typical pattern of steep, eroded banks that alternate with sand point bars and willow thickets. A few small oxbows are also found along the river in the upper Coastal Plain. The character of the fish community is altered by these habitat changes.

It is often assumed that the shoal bass population declines as shoal habitat disappears below the Fall Line. Data indicates that shoal bass are common in the Coastal Plain section of the upper Flint River from Hwy. 128 to Montezuma, and their average size is larger than in the Piedmont. At present about 40 percent of Coastal Plain shoal bass are in the larger 14 - 20 inch class and about 5 percent are in the trophy category over 20 inches. Shoal bass in Coastal Plain areas prefer swifter water near the banks, almost always in association with larger snags. Few shoal bass will be found in other habitat types. Largemouth bass are about equally abundant in Piedmont and Coastal Plain sections and they typically outnumber shoal bass below the Fall Line. Currently, about 20 percent of the largemouth are in the 12 – 15 inch class and 15 percent are between 15 - 20 inches.

Redbreast are equally abundant in the Piedmont and Coastal Plain and sizes are similar. Bluegill outnumber redbreast below the Fall Line and recent samples indicate that they are exceptionally abundant in the area between Hwy. 96 and Lake Blackshear. Bluegill fishing in this section of the Flint River is probably one of your best bets in 2006.

Good channel and flathead catfish populations are found from the

Fall Line to Lake Blackshear, and are generally associated with accumulations of snags in the well defined, deeper outside bend areas. Major access points in the upper Coastal Plain between Hwy. 128 and Lake Blackshear are at Hwy. 128, Hwy. 96, Macon County Ferry Road, Montezuma Bluff, Hwy. 49 between Montezuma and Oglethorpe and Reeves Landing.

In summary, on the Flint River you can have your choice - the picturesque shoals and rugged, forested hills of the Piedmont, or the lazy meandering river of the upper Costal Plain. There is plenty of good fishing to experience in both areas, and 2006 should be a good year for the Flint River. Please contact the Fort Valley office of the Fisheries Management Section (478-825-6151) for more information on planning your fishing trip on the upper Flint River.

Flint River (lower)

The Flint River has long been recognized for its outstanding shoal bass fishery. This unique bass is native only to a few rivers in Georgia, Alabama, and Florida. The current Georgia record shoal bass, caught on the Flint River in 1977, weighed an impressive 8 lbs. 3 oz. The best time of year to catch shoal bass is the summer (May-July) and fall (Sept.-Oct.) and some of the best action can be found in the shoal areas below Newton (Baker County) and immediately upstream of Hwy. 32 in Lee County. In addition, the small islands found upstream from the mouth of Ichawaynochaway Creek are good places to find shoal bass. Anglers should encounter an abundance of 12-15 inch fish this year. Relative high water conditions during the late spring and early summer in 2005 may impact recruitment of young shoal bass. In addition, the number of shoal bass over 15 inches sampled during electrofishing surveys was up more than 50 percent from the previous year. A greater number of larger fish in the population, combined with decreased fishing pressure due to high water conditions during the summer of 2005, may increase anglers' chances to harvest a trophy size (>3 lbs) shoal bass during 2006. Shoal bass feed heavily on crawfish, so jigs and soft plastics in crawfish patterns are favorites among anglers. Small crankbaits and topwater lures can be very productive as well. Fly-fishing is a challenging and increasingly popular way to fish for shoal bass. Woolly Buggers should be a standard in any fly box.

Although largemouth bass don't receive the same attention as do shoal bass, fishing can be good in certain areas along the Flint. For quality largemouth, anglers should try the two-mile stretch of river below Warwick dam. Bass fishing is often overlooked during the winter months. However, this can be a good time to fish, as bass often will congregate around the many springs in the river, which remain a constant 68°F.

Beginning in late February, white bass, striped bass and hybrids begin their run up to the Albany dam. Most people cast bucktails for hybrids and striped bass, but crankbaits like shad raps and rapalas work well too. Most stripers will be in the 16-20 inch range and weigh less than 4 lbs. However, a few fish over 20 lbs. are caught each year. Both striped and hybrid bass numbers are good, and this should result in better than average fishing opportunities for these species in the spring of 2006, below the Albany dam. Anglers should also expect to catch good numbers of hybrid and striped bass (less than 10 lbs.) in the tailrace below the Warwick dam during the spring and summer of 2006.

Flathead catfish are also a favorite among Flint River anglers. The number of flatheads has remained high and stable over the last several years, but big flatheads (greater than 20 lbs.) are rare. Most of the flatheads caught in 2006 will range from 20-24 inches and weigh less than 5 lbs. The best fishing usually takes place during the summer months when flatheads occupy the deeper holes in the river. Live bait is a must, with bream being the bait of choice. Some of the more productive areas can be found downstream of Hwy. 32 in Lee County and the river section above Newton in Baker County.

Based on angler creel data and WRD sampling data, channel catfish are another species that is abundant and available to Flint River anglers. That portion of the Flint River below the Warwick dam is very productive and popular with local anglers. This area, as well as the entire Flint River, should have good numbers of harvestable-sized channel catfish available to anglers during 2006. Anglers bottom fishing with baits such as worms, chicken liver, or dead shrimp should be successful fishing both immediately above and below the numerous shoals found throughout the lower Flint River.

High water conditions during the spring and summer of last year resulted in decreased fishing pressure for bream during 2005. Decreased fishing pressure combined with the added productivity created by high water conditions, should result in above average bream fishing in 2006. In addition, the average size of redear, bluegill and redbreast sunfish should be up from previous years. Snags and blowdowns in the river section above Lake Blackshear and upstream from Lake Worth to Abram shoals offer good fishing spots for bluegill. Redbreast sunfish are more abundant in and around the shoal areas of the river and redear sunfish can be found throughout the lower Flint River from Lake Blackshear downstream to below Newton.

Ochlockonee River

The Ochlockonee River may not be as familiar to most as other major rivers in South Georgia. However, this slow-moving blackwater stream offers good fishing for redbreast sunfish. Traditionally, redbreast are more numerous in the lower portions of the river, from Hwy. 93 to Hadley's Ferry Road. Anglers will usually fair better using live crickets and worms during early spring and switching to artificial lures, such as beetle spins and popping bugs, as spring progresses and water temperatures rise. Anglers fishing for bream should have similar success during 2006 as they did during the 2005 season. Although not as abundant as redbreast, anglers can expect to catch several other sunfish species including bluegill, redear sunfish, spotted sunfish, warmouth and black crappie.

The Ochlockonee River has a fair largemouth bass population. The backwater areas near Thomasville and the section of river upstream from Hwy. 93 are good largemouth bass locations. Anglers fishing the Ochlockonee often will encounter a unique member of the sunfish family, the Suwannee bass. The Suwannee bass is smaller than its cousin, the largemouth bass, and is found in only a few streams in South Georgia and north Florida. The overall population of Suwannee bass in the Ochlockonee is relatively low, but it did provide the current state record Suwannee bass (3 lbs. 9 oz.) in 1984. Suwannee bass typically prefer swifter water, but as the summer progresses and the river recedes they can be caught in the deeper pools using small crankbaits and soft plastics.

Anglers looking to catch a mess of catfish would be wise to try the Ochlockonee during warmer months. Your favorite catfish bait fished on a simple bottom rig should be effective on a variety of species including channel catfish, white catfish, and bullheads. Thankfully, there are no confirmed reports of non-native flathead catfish in the Georgia portion of the Ochlockonee. Anglers who suspect they have caught a flathead should keep the fish and call the Albany Fisheries Management Office (229) 430-4256 as soon as possible.

Ocmulgee River (upper)

The Ocmulgee River begins its long journey through central Georgia under the waters of Lake Jackson at the junction of the Yellow, South and Alcovy rivers. From Lloyd Shoals Dam at Lake Jackson the Ocmulgee River flows southeast through the scenic shoals of the Piedmont for 36 miles before crossing the Fall Line just above Macon. Below Macon the character of the river changes dramatically as the floodplain widens to produce river bottom swamps and the shifting channel meanders between sand bars, willow thickets, steep banks, and backwater sloughs. The Ocmulgee River from Lloyd Shoals Dam to Hawkinsville has two characters, delineated by the Fall Line and providing distinctly different fishing opportunities. Anglers in central Georgia have the unique opportunity to experience each within a short drive from Macon, Warner Robins, or Perry.

Lloyd Shoals Dam is one of Georgia Power Company's oldest hydroelectric dams and provides the backdrop for a fishing trip to the productive tailrace area. A metal weir has been constructed across the channel just below the dam to improve dissolved oxygen levels and the success of the project is evident in the number of fish that have re-entered the area. A long catwalk was built along the west bank adjacent to the weir to provide a comfortable fishing area for bank anglers. Expect to catch bluegill, crappie, catfish, and hybrid striped bass (hybrids) here throughout the year, with the best catches in the spring.

In 2005 a mixture of striped bass and hybrids was stocked in Lake Jackson to provide added trophy potential to the reservoir fishery and to help improve the striped bass population in the Altamaha River system. Hybrids alone have traditionally been stocked in Lake Jackson and escapement from the reservoir has resulted in significant numbers of hybrids entering the Lloyd Shoals Dam tailrace fishery. The added presence of striped bass in 2006 will provide a new and exciting opportunity for the Ocmulgee River fishermen. Expect striped bass stocked in Lake Jackson in 2005 to average about 12 inches in the spring of 2006, but some of the stripers that escape into the river may exceed 30 lbs. in the next 8 – 10 years.

Georgia Power has provided an excellent boat ramp and picnic area on the east bank just below the dam and motorboat anglers launching here have access to about 0.7 miles from the weir to a major shoal at Hwy. 16. Hybrids traditionally stack up at the base of the weir and in 2006 you can expect to catch small striped bass as well. Largemouth bass, bluegill and shellcracker are numerous in the calmer waters along the banks. As the current picks up near the shoal at Hwy. 16, expect excellent catches of redbreast and a few shoal bass during the April –June period. Spotted bass were apparently stocked into Lake Jackson by fishermen in the 1980s and are now found in the upper Ocmulgee River as well. They are most abundant near Lloyd Shoals Dam in areas with moderate current.

Although motorboats are limited to the deeper water above Hwy. 16, canoes can float over the shoals and continue downriver to takeout locations at Wise Creek and Hwy. 83. The section from Lloyd Shoals Dam to the Wise Creek Recreation Area (5.3 miles) is an easy one-day float, but those taking out at Hwy. 83 (14.5 miles) should plan on spending one night on the river. It is probably no exaggeration to state that the area of alternating shoals and flat water reaches between Hwy. 16 and Wise Creek may provide one of the best angling experiences in Georgia. Your biggest problem with fishing this area may be deciding if you had rather fish for shoal bass or redbreast, but you might catch a limit of both on a good day in May or June. Most shoal bass will be in the 11 – 13 inch range, with about 10 percent between 14 - 16 inches and the occasional lunker from 17 - 20 inches. Redbreast will average about 5 inches.

Preferred shoal bass lures are small to medium swimming minnows, spinner baits, poppers and artificial worms. The fly fisherman should bring plenty of wooly buggers and medium poppers. Crickets are the traditional redbreast bait, but ultra light tackle with small spinners or fly-fishing with small poppers or spider imitations can sometimes be just as productive. As an added incentive for a trip to this area, the U. S. Forest Service has recently upgraded the canoe access facilities at the Wise Creek Recreation Area located on the east side of the river on the Oconee National Forest. The recreation area can be reached off of Clay Road between Hwy. 83 and Hwy. 16. Excellent wade fishing for shoal bass and redbreast is available for anyone willing to tackle the one half mile upstream paddle to a large shoal area.

Access is relatively limited for the remainder of the Piedmont section of the Ocmulgee River from Hwy. 83 to Macon. The longest reach accessible to motorboat anglers is a 10-mile section both up and downstream of the ramp at Hwy. 83, but sand flats and obstacles at low flows requires caution. The lower end of this section can also be reached from a boat ramp just above the Juliette Dam A one-mile section in the vicinity of Popes Ferry is the only other area accessible to motorboats. The remainder of this reach is strictly canoe or kayak country. For an easy float trip try the four-mile section between Hwy. 83 and the ramp just above the Juliette Dam. For the more adventurous, consider the nine miles from the canoe launch site just below the Juliette Dam to Popes Ferry, or the 14 miles from Popes Ferry to Spring Street in Macon. Although there are no major whitewater challenges on the Ocmulgee River, shoals are numerous and could easily capsize a kayak or especially a heavily loaded canoe. A major drop just below Dames Ferry at Hwy. 18 should be carefully scouted before proceeding.

For those without a boat the shoals just below the Juliette Dam can be accessed for wade fishing from a canoe launch site just below the dam on the east side. The quarter mile area below the dam provides excellent shoal bass and redbreast fishing and as an added bonus the American shad, striped bass and hybrids concentrate at the base of the dam during March – May. The Juliette Dam is the first barrier on the Ocmulgee River encountered by American shad on their long spawning runs up from the Atlantic Ocean. The dam is a frustration for the shad but a boon for anglers since it concentrates the fish in numbers large enough to be caught on spinning tackle using "shad darts" or on a fly rod with small streamers. American shad fishing is as popular as bass fishing in some parts of the country, but they receive little attention in Georgia. For a new fishing experience try the American shad below the Juliette Dam. They will average 20 inches and a little over 2 lbs. and are sporting on light to medium tackle. Many consider them excellent eating and there is a generous eight fish daily creel limit. American shad are found below the Juliette Dam in most years from March through early May but are most abundant during the peak of the spawning run in April.

Historically a modest spring run of striped bass and hybrids has existed below the Juliette Dam with a few stripers caught in the 10 - 20 lbs. class and the hybrids averaging 5 – 6 lbs. Escapement of striped bass stocked in combination with hybrids in lakes Jackson, Tobesofkee and High Falls beginning in 2005 should improve the striped bass fishery in the Ocmulgee River below the Juliette Dam during the next several years. Hybrid stockings in these lakes will be gradually phased out and replaced with equal numbers of striped bass within the next 2 – 3 years. Additional sources of striped bass to the Ocmulgee River are from Lake Juliette where they have been stocked for over 20 years, Lake Sinclair on the Oconee River where stockings began in 2005, and recent stockings in the lower Altamaha River. The Ocmulgee River fisherman should definitely benefit from these efforts by WRD to improve the status of striped bass in the Altamaha River system. Imagine battling 30 lbs. striped bass in the swift waters of the Ocmulgee River – it could happen within a few years.

Expect to find shoal bass and redbreast near any shoal throughout the lightly fished area between the Juliette Dam and Macon. Although shoal bass are favored by most fishermen in this section, largemouth bass, redbreast and bluegill are often abundant in the calmer sections along the banks. While paddling between shoals searching for your next shoal bass, it often pays to cast a spinner bait, topwater plug, or worm next to a snag in one of the slack water sections. About 30 percent of the largemouth bass in this area are 12 – 15 inches, over 20 percent are between 15 - 20 inches, and about 10 percent are in the 20 – 25 inch category.

The bedrock outcrops and shoals of the Piedmont come to an abrupt end about seven miles above Macon near Arkwright. A relatively unproductive transitional zone of shallow sand flats forms below the last shoal near the River North Bridge and continues down to the vicinity of Spring Street in Macon. The true upper Coastal Plain section of the Ocmulgee River begins at Macon and continues for about 70 miles to near Hawkinsville where the character of the river begins a transition to the lower Coastal Plain. In any given year, the quality of fishing below Macon to Hawkinsville can range from fair to excellent, with year class strength of most sport fish dependent on good spawning flows followed by periods of floodplain inundation during the summer to early fall growing season.

Although shoal bass are found below the Fall Line and are fairly common as far down as Warner Robins, largemouth bass are the predominate black bass below Macon and good catches are possible using the right techniques. Most of the larger snags along the bank, particularly in areas of low current velocities, are home to one or more largemouth bass and they can be fooled with a lightly weighted plastic worm or lizard cast as close to the structure as possible. Spinner baits, medium rapala-type crank baits, and plastic jerk baits are also effective, but the key is getting the lure deep into the cover.

Although largemouth bass can be caught at any time of the year, periods of low to moderate flows in the late spring or fall are best, followed by the summer period. At least moderate water clarity is critical for success, and flows are usually too high and muddy in winter and early spring. Please remember that the largemouth bass length limit is 12 inches above the Spring Street Bridge in Macon and 14 inches below. Recent sampling conducted by WRD has found that about 30 percent of the largemouth bass below Macon are in the 8-12 inch range, 20 percent between 12 -15 inches, and 20 percent between 15 - 20 inches. A few monsters in the 20 – 25 inch class can also be found hanging close to the snags.

Redbreast and bluegill are other popular targets in this section of the Ocmulgee River, and although May and June are the most productive months they can be caught in good numbers from spring through fall. Shellcracker can also provide some fine fishing during the late April – early May spawning season, if you can locate their spawning beds in the shallow, calmer water near the main channel. Expect redbreast to average about 5 inches, bluegill 5 – 6 inches, and shellcracker 8 – 9 inches. The exotic longear sunfish has been increasing in abundance for the last several years and is now found throughout the length of the Ocmulgee River. In some locations it has become the dominant sunfish species. Although one of the most colorful of all sunfish, most are under 4 inches in length and can generally be considered a nuisance. This is an example of the undesirable effects of exotic fish introductions.

Catfish help round out the fishing scene on the upper Ocmulgee River. Channel catfish are abundant throughout the length of the river and although rod and reel fishing can be effective, most use trotlines or bushhooks baited with prepared baits, liver, crayfish, and a variety of "home recipes". Flathead catfish have colonized most of the Altamaha River system since their introduction in the 1970s, but until recently they were not found above East Juliette because the Juliette Dam blocked upstream passage. Recent sampling conducted by the WRD has documented the presence of flatheads above the Juliette Dam and their numbers in this area should increase dramatically in the next several years. Flatheads are most abundant below Macon where they may reach weights of over 80 lbs. and these are by far the largest sport fish found in the Ocmulgee River. They can be caught with rod and reel as well as bushhooks and trotlines, but regardless of the gear, live bait must be used and the most effective is probably a medium size redbreast or bluegill.

In summary, the upper Ocmulgee River is one of middle Georgia's most valuable natural resources and a premier fishing destination. Whether it's an exciting kayak float trip for shoal bass in the Piedmont, fishing for American shad below the Juliette Dam, or a johnboat excursion along the meandering channel to a secret spot below Macon, the Ocmulgee River will draw you back time and again. Please contact the Fort Valley office of the Fisheries Management Section (478-825-6151) for a map of access points and other information on planning your fishing trip to the upper Ocmulgee River.

Ocmulgee River (south of U.S. Hwy. 280)

The Ocmulgee River below Abbeville is large and sluggish with many meandering bends and some oxbow lakes. One such lake, Montgomery Lake, produced the current world record largemouth bass (22 lbs. 4 oz.) in 1932. It is unlikely this lake will produce another world record bass, but the opportunity to fish this area still awes and excites many bass anglers. Anglers unfamiliar with the river should obtain the free brochure, *A Guide to Fishing the Lower Ocmulgee River*. This guide contains a map of the river showing locations of improved boat ramps and is available from any WRD Fisheries Section office.

The Ocmulgee River has something to offer all anglers. Whether you prefer casting for that lunker bass, pitching a cricket for redbreast or bluegill, or maybe even setting a trotline for catfish, you need to try fishing the lower Ocmulgee River. Fishing in the lower river should be better than ever for several species in 2006.

The number of bluegill collected from the Ocmulgee by WRD biologists this past year was three times higher than the average catch. Most of the increase was for fish in the 3-6 inch range, but the number of fish in the 7-10 inch range was also greater than last year. All of the fish collected were fat and healthy. Bluegill fishing should be better in 2006 and many fish should tip the scales at nearly a pound. If we have a normal period of high water in the river this spring, the smaller fish should grow rapidly and contribute to the fishery. The best time to fish for bluegill is between mid-April and mid-June. Popular baits include crickets and catalpa worms fished near the bottom below a light cork. Try pitching your bait around cover along the shoreline in oxbow lakes, sloughs, slack-water areas or eddy pockets.

The number of redbreast sunfish collected last fall by WRD biologists was slightly above average and the fish were larger than last year. Since more large fish are available in the population, expect redbreast fishing to be a little better than last year. Popular techniques for catching redbreast include fishing crickets or worms in flowing water around structure along creek and river channels. Also, try the head and tail ends of sandbars. Fish your bait suspended below a float just above the bottom or straight-lined on the bottom.

The redear sunfish (shellcracker) population remains remarkably stable from year to year. The Ocmulgee produces a good number of fish in the 9-12 inch range that tip the scale at 1-2 lbs., and this trend should continue in 2006. Shellcrackers are not as abundant as redbreast and bluegill, but they make up for it with their larger size. The best fishing will occur in early spring when they move into shallow water in sloughs and oxbow lakes to spawn. Favorite baits include red wigglers or crickets fished near the bottom under a cork.

Later in the summer, fish around woody debris and overhanging vines along the riverbank. In the fall, try fishing around flooded grasses and vegetation near the mouths of oxbow lakes and creeks.

The number of largemouth bass of all sizes collected last fall was the highest ever recorded and more than twice the number collected last year. Bass anglers will be glad to know the number of harvestable bass increased and they are fat and healthy. Expect most of the bass caught to be in the 14-16 inch range, but be ready for the occasional lunker. Our sampling consistently locates several fish in the 7-10 lbs. range each year. Oxbow lakes and slack-water areas containing overhanging willows and woody structure are popular fishing locations, especially in the spring. Later in the summer, try fishing eddy pockets, the downstream end of sandbars and heavy cover along the banks. Popular lures include crankbaits, spinnerbaits, plastic worms and lizards.

Catfishing in the Ocmulgee River should be better in 2006. There are a good number of quality channel catfish in the river, but expect most to be in the ½ - 2 ½ lbs. range. The flathead catfish population has been increasing in recent years and there are good numbers of fish in the 4-10 lbs. range. Since flatheads have reduced the abundance of sunfish populations, WRD encourages anglers to fish for and harvest them. Remember, it is illegal to move flathead catfish from one river to another. All sizes of flatheads make good table fare. Anglers commonly catch flatheads on heavy-duty sporting tackle and on limb or trotlines. Live bait works best. Try fishing shiners, bream or Louisiana pinks around snags in the deep holes along outside bends of the river channel during the day. Flatheads tend to move into shallower water to feed after dark and you will have to move with them to be successful. You can catch flatheads year-round, but the best time is from late winter to late summer. For more information on flathead catfish, including additional fishing techniques and tips, obtain a free copy of *A Flathead Catfish Fishing Guide* from your nearest WRD Fisheries Management Office.

Regardless of your preferred species and fishing method, a trip to the Ocmulgee River should be an enjoyable fishing experience. Fishing should continue to be good in 2006, especially for bluegill and largemouth bass, so get out there and take advantage of the varied fishing opportunities available on the Ocmulgee River and enjoy the available resource.

Oconee River

The Oconee River headwaters begin in Hall and Gwinnett counties northwest of Athens and flows southwest for about 265 miles were it joins the Ocmulgee to form the Altamaha River. The Oconee River is regulated through two major dams. The upper Wallace Dam was constructed in 1980 creating Lake Oconee and below is Sinclair Dam constructed in 1953 forming Lake Sinclair. Fishing opportunities are somewhat different, along with the river appearance, above and below these dams. Above, the upper Oconee River flows through the Piedmont Region where you will find bedrock outcroppings, stable bank cover, and a gravel or sand bottom. Shortly below the Sinclair Dam, the lower Oconee River finds itself flowing through the Upper Coastal Plain. Cutaway sand banks/bluffs, fallen woody debris, and a river bottom consisting of primarily sand and silt define this area. Fishing opportunities and tactics between the upper and lower Oconee River will vary due to unique habitat differences.

Fishing predictions have historically been reported in the lower Oconee River but at certain times of the year, the upper Oconee River may offer the best opportunity to catch a stringer of fish. Most notable is the excellent white bass and crappie fishing opportunities in the stretch of river above Lake Oconee to Barnett Shoals Dam below Athens. The best time to fish this area is between mid-February to late-April. Small chartreuse screw-tail jigs are the preferred bait for both white bass and crappie and live-minnows are always a good bet when jigs are not working. Popular boat ramps in this area are Hwy 15 and Dyar Pasture and both are located between I-20 and Athens.

Bass and bream fishing opportunities are also available on the upper Oconee River. Redeye bass can be found in the swifter water sections having bedrock outcroppings and largemouth bass in slacker water areas around woody cover. Small soft plastics, large spinners and shallow diving crankbaits are always good choices. Panfish anglers should also expect to catch plenty of colorful sunfish using ultra light gear rigged with a small rooster tail or beetle spin. In areas of the Upper Oconee having bedrock shoals, a popular tactic for catching both bass and bream, involves wading the shoals with a 6- to 8-weight fly rod rigged with a small popper. Regardless of tactics or type of fish you are targeting, a fishing trip on the Upper Oconee will result in a pleasant outdoor experience.

The fish population in the Lower Oconee is generally smaller than other rivers in Georgia. However, the opportunity to catch a limit of nice fish is still good, and if your a fisherman who likes to be on the water without a large amount of angling pressure, the lower Oconee River may be just what you looking for.

Angler catches of panfish in the Lower Oconee, especially bluegill, should be good in 2006. About 38 percent of the fall 2005 fish collections were comprised of bluegill. Of the bluegill collected, most (71%) were less than 6-inches and the remaining (29%) bluegill collected ranged from 6-10 inches. Panfish anglers still may find it difficult to catch a stringer of redbreast in 2006. Only 16 percent of the overall samples were redbreast, and 73 percent of the fish collected were less than 6 inches. Longear sunfish are another colorful panfish that have become prevalent in the Lower Oconee. They comprised 17 percent of the total fish collections and about 26 percent of the fish collected were hand size (5-6 inches). Anglers wishing to target Lower Oconee panfish should try fishing close to cover with catalpa worms or crickets using a split-shot and a float above the hook. The best locations can generally be found near creek mouths or deep eddy pools near swift current.

The largemouth bass population in the lower Oconee River continues to be comparable if not better than most rivers in the upper and lower coastal plain, yet receives the least amount of bass fishing pressure. Over 19 percent of fish collected in fall samples were bass. Most (67%) of the fish were greater than 12-inches, 28 percent were greater than 14-inches, and about 10 percent were greater than 20-inches (or four pounds). Classic baits for fishing these swift-water bucket mouths are a chartreuse/white snagless sally, spinnerbaits or pig and jig. For a good start, try fishing the shoreline having fallen trees with moderate current and gradually work your way into slacker water areas having good cover.

Crappie may also provide a good fishing opportunity in the winter and early spring before the bream and bass fishing picks up. Crappie make up a small percentage (< 5%) of our fish collections, but 75 percent of the fish were quality greater than 8-inches and 40 percent were greater than 10-inches. Anglers will be most successful by fishing woody cover in slack water areas with live minnows and artificial jigs.

Although catfish were not targeted in standardized sampling, a large number of channel catfish ranging from 2-4 lbs. and several flathead catfish were observed. The flathead catfish grow to a very large size, presenting an opportunity to catch a trophy-sized fish. Most success for flatheads comes from fishing limb lines or trot lines set overnight and baited with a hand-sized live bream. Flathead catfish are an introduced predator to the Oconee River, and anglers are encouraged to harvest any flatheads they catch.

Overall, fishing conditions in the Oconee River are slightly down from 2005 but should provide good fishing action for bluegill, largemouth bass, and channel catfish. In general, fishing for most species in the lower Oconee is better in the river below I-16 (south of Dublin), and fishing in the upper Oconee River should remain good in most areas depending on the time of year.

Ogeechee River (upstream of U.S. Hwy. 17)

Unlike most rivers in Georgia, the flow of the Ogeechee River is not regulated by dams. This allows the river to rise and fall according to the amount of rainfall in its watershed. This natural fluctuation in river level plays a big role in fish growth and fishing success. Average rainfall in the Ogeecheee basin was experienced in 2005. This produced some periods of out of bank flows on the Ogeechee. Floods allowed the fish to benefit from the rich food source located in the flood plain, which resulted in good growth.

Traditionally, the Ogeechee River has had an excellent redbreast sunfish fishery. During low flow periods, redbreasts are able to reproduce very efficiently. Out of bank flows allow these smaller fish to utilize the vast resources of the flood plain and put on some serious growth. Fishing for all species should be excellent in 2006. Look for good numbers of hand-sized redbreast sunfish and bluegill with an occasional rooster red. For some steady redbreast action, try fishing in the mouth of small channels where ever the river splits. These areas usually provide excellent redbreast fishing.

Other panfish species present include bluegill, redear sunfish (shellcracker), black crappie and spotted sunfish (stump-knockers). Anglers should concentrate their efforts for bluegill and redear fishing upstream of Midville, near the Jenkins County line, to McCroans Bridge, south of Louisville. In addition, good-sized fish can also be caught in the brackish water tidal area around US Hwy. 17. Scattered pockets of black crappie provide exciting cold weather fishing from Hwy. 204 upstream as far as Jenkins County. Live bait works well; however, grubs and small screw-tail jigs can also produce nice size crappies. Although smaller than other popular panfish, the spotted sunfish is plentiful in the backwaters of the Ogeechee and should not be overlooked. There is a reason they call them a stump-knocker. They stay very tight to cover.

The Ogeechee River has never been viewed as a major largemouth bass stream among anglers fishing coastal freshwater rivers. Less than three percent of the angler harvest is made up of largemouth bass. However, Ogeechee largemouth bass are plentiful and healthy. Look for some excellent bass fishing in the spring as water temperatures rise. April is usually the month when the largest numbers of bass are caught. Take some time this spring to tap into this unique largemouth bass fishery. Work the banks with spinner baits or flip a jig and pig into those tight places where big bass love to hide. Try fishing the railroad trestle up stream of the boat ramp on Hwy. 56 in Midville for some trophy river largemouth. Largemouth bass in the 6 lbs. range are common in this area.

Catfish are plentiful, with snail bullheads and white catfish being most common. Like redbreast sunfish, catfish are most concentrated where there is a combination of swift water and heavy cover. Bullheads are numerous throughout the river, but white catfish abundance increases as you get closer to the estuary. Most of the large catfish are channel catfish. Try using cut bait or live minnows in the outside bends of the river to catch these large fish.

Flathead catfish are not native to the coastal river drainages of Georgia. Flatheads are not established in the Ogeechee. An illegal introduction of flathead catfish into the Ogeechee would be devastating to the fish populations. Anglers need to be aware of the consequences of an illegal introduction of flathead catfish. Once introduced, flathead catfish are impossible to completely remove. The redbreast sunfish and bullhead populations are most impacted. It is very important that flatheads **not** be introduced into the Ogeechee River. If you have any information about anyone moving flathead catfish, please call the TIP number 1-800-241-4113, 24 hours/day, 7days/week.

Oostanaula River

The Oostanaula River originates at the confluence of the Conasauga and Coosawattee Rivers northeast of Calhoun, Georgia. It winds southward approximately 49 miles to Rome, Georgia where it merges with the Etowah River to form the Coosa River. A map of boat ramp locations is found in the publication "*A Guide to Fishing the Oostanaula River*" available on the WRD website at www.gofishgeorgia.com, select "Fishing," then "Lake, Reservoir, River, Public Fishing Area Items," then "Georgia River Fishing Information" and "Oostanaula River." This document contains access and fishing tip information, as well as a color map with river-mile designations. This is definitely a small boat river and care should be taken when navigating, especially in the summer low water period.

The Oostanaula is once again home to a sportfish species that disappeared from the river nearly 40 years ago. Since 2002, 41,000 plus lake sturgeon have been re-introduced to the Oostanaula River and other rivers in the greater Coosa River basin. Pollution and overfishing are believed to have eliminated most of these archaic fishes from the river system in the 1960's. Thankfully since then, water conditions have improved in the river. Through long-term annual stocking it is hoped the species will reclaim much of its historic inhabitance within the river. The species grows slowly and does not mature for 12-15 years so it is important to protect them from harvest until they can reproduce and once again support some angler harvest. Anglers accidentally catching a lake sturgeon should immediately release the fish unharmed. Fish hooked deep will often survive if anglers will cut the line near the hook and release the fish with the hook. If you catch a sturgeon, please contact either WRD office listed above to report the location from which the sturgeon was caught. Such "sightings" help biologists assess the status of these magnificent fish.

Anglers will likely be most successful in the pursuit of catfish on the Oostanaula. Channels, blues, and flatheads inhabit its murky recesses year-round. Fisherman often find the largest individuals hold-up in deep pools, undercut banks, and in logjams, especially those with good flow around them. All sized cats will move from these hideouts in the morning and evening to feed around shoals and other shallow habitats. Blue and channel cats occur in similar numbers, with blues averaging 1 lb. and channels nearing ¾ lb. Larger blue cats in the 5-8 lbs. range are somewhat common, with individuals over 10 lbs. being considerably less common. Flatheads are present, yet in much lower numbers than either blues or channels. Live bait is a must for those looking to boat flatheads with regularity.

The muddy waters of the Oostanaula provide only fair to poor black bass fishing opportunity for northwest Georgia anglers. Nearly 80 percent of the black bass population is made up of spotted bass averaging 7-8 inches long. The less common largemouth has an average length of 12 inches and weighs in at just over a pound. Largemouth are more common in the lower reaches of the river while spots, despite being found throughout, are most numerous in the 4-mile stretch above and below state Hwy. 140. Target these fish around creek mouths, debris jams and around overhanging vegetation and fallen trees. Small numbers of redeye bass are resident to the river section between Georgia Hwy. 225 and Hwy. 156. However, redeye fisherman will have greater success targeting these natives in the many tributaries feeding the Oostanaula.

Oostanaula bream anglers will find low to moderate numbers of bluegill, and still fewer numbers of redbreast, redear (shellcrackers) sunfish and crappie. Bluegill fisherman will typically find fish averaging 5 inches, with "gills" over 7 inches being rare. Target bream in slow water areas around creek mouths and the slack-waters behind debris jams.

Stripers will move into the lower Oostanaula around Rome, Georgia to spawn in April and May. Bucktails and live or cut shad can be effective patterns for the spring striper fisherman. Be sure to use stout fishing gear to prevent these behemoths from breaking you off around the log jams and tree canopies they frequent. After the spawn, stripers disperse throughout the Coosa River system seeking cool water in which to beat the summer heat. Small stripers may be caught in the Oostanaula during the summer, but the premier fishing will be in the spring months.

In the spring, small numbers of white bass will move into the Oostanaula to spawn. Success during this time can be sporadic for the inexperienced. White bass anglers should instead consider fishing downstream in the Coosa River. Larger numbers of white bass can be found there during the spawn in the area at or below the Rome Lock and Dam. Boats can be launched from the Lock and Dam Park or downstream at the Old River Road boat ramp off state Hwy. 20 west of Rome, Georgia. These concentrated spawn-run fish can be caught using small jigs and crankbaits in addition to live baits

Smallmouth buffalo, freshwater drum, carp, and suckers dominate the relatively slow moving waters of the Oostanaula. Drum average 12 inches in length with larger "bull" drum exceeding 20 inches. Those wishing to catch drum should target the swifter waters and shoals of the Oostanaula using live crayfish, cut mussels, shrimp, or small jigs fished along the bottom.

Satilla River

The Satilla River is one of the premier redbreast sunfish rivers in the Southeast and is your best bet for catching a redbreast sunfish weighing over one pound. High water levels were present throughout much of 2005 provided excellent conditions for growth and survival. Samples revealed the highest numbers of redbreast observed in 10 years. However, the average size of the fish collected had increased. This winter the Satilla River has remained relatively high, with the occasional rain event periodically pushing the river back into the floodplain and providing optimal conditions for growth. Anglers should once again catch large numbers of harvestable sized redbreast in 2006 and their stringers should include good numbers of fish 8 inches or larger. The best redbreast fishing will be in the section of river above the US Hwy. 82 Bridge near Atkinson. In spite of WRD's flathead catfish removal program, flatheads have become well established below US Hwy. 82 and have noticeably reduced the abundance of redbreast sunfish in this section of the Satilla.

If you are looking for a cure for your "cabin fever," a few redbreast can be caught in March by fishing worms or crickets on the bottom. For anglers who prefer to wait for peak fishing, April and May are typically the best months. Fishing usually peaks when the water warms and recedes well within the banks (usually about 4½-5 feet at the Waycross river level gauge). The best method is fishing with crickets and worms under bobbers or on the bottom with split-shot weights. As water temperature increases into the 70s, anglers often switch to artificial lures such as small beetle spins and rooster-tail spinners. Fly-fishing can be very effective after the water warms. Try popping bugs on a fly rod to lure some true "rooster reds."

Although other bream species such as bluegill and spotted sunfish (stumpknockers) receive less attention than redbreast, they are plentiful. These populations also need high water conditions in the winter and spring to produce large numbers of quality sized fish. Therefore, anglers will most likely bring home good catches of bluegill and other bream in 2006. Oxbow lakes and beaver ponds off the main river channel are prime locations for catching a good mess of panfish. Oxbow lakes in the lower sections of the river around the Burnt Fort area provide some of the better bluegill fishing. Crickets and worms are productive baits.

When conditions are too cold for good catches of bream, largemouth bass and catfish, try fishing for crappie. Crappies are present throughout the river, fishing woody cover in slack water away from the main channel being the best bet. Live minnows and small artificial jigs are top producers for crappie.

While not known for its bass population, the Satilla usually contains sufficient numbers of largemouth bass to provide an enjoyable outing. The largemouth bass population numbers have also recovered due to the high water conditions that have been present over the last few years. The majority of the bass on the business end of the anglers line will probably be fairly small (10-12 inches). However, anglers will occasionally set the hook on lunker bass. Largemouth bass fishing peaks in late winter and early spring when river levels are too high for successful bream fishing. Typical bass lures work, but it is hard to beat a shallow-diving minnow plug in the spring of the year.

Catfish fishing should remain very good this coming year. The river supports healthy populations of snail, yellow and brown bullheads and channel catfish. Use worms, chicken livers, cut bait or your own secret bait fished on the bottom in deeper holes (usually on outside bends in the river).

Thus far, the flathead catfish does not appear to have affected the redbreast sunfish population in the prime redbreast habitat of the upper river (above US Hwy. 82) because flathead numbers still remain low. However, the flathead catfish population in the Satilla is steadily gaining dominance as has occurred in other southern rivers. Flathead catfish are captured (by electrofishing), data is collected, and the fish are donated to local food banks. **Please harvest all flathead catfish you catch. Do not release any.** They are very good to eat.

It is illegal to move fish from one lake or stream to another. Moving fish can cause unexpected and irreversible changes to the fish populations. If you have information about anyone moving flathead catfish please call **1-800-241-4113** (24 hours/day, 7days/week).

A *Guide to Fishing the Satilla River* is available. It contains a map, access sites, and helpful fishing tips. Call a Fisheries office for a free copy.

Savannah River
(Downstream of New Savannah Bluff Lock & Dam)

Flows in the Savannah River, below the New Savannah Bluff Lock & Dam, are heavily influenced by releases from Clarks Hill (Strom Thurmond) Dam. Angler success for many species is dependent upon river levels. Fishing is usually best when river levels drop within 5-6 feet on the USGS flow gauge at Clyo. Check local forecasts for river stage information. Many anglers find that numerous oxbow lakes along the river provide excellent fishing opportunities. River oxbows created by COE channel modifications in the late 1950s and early 1960s are recognized as shared waters under the agreement between Georgia and South Carolina. State boundaries did not change as a result of these channel modifications, but run down the middle of these old oxbows. Anglers should refer to USGS topographic maps and carefully identify these man-made oxbows. Some of the old natural oxbow lakes exist totally within the boundaries of South Carolina and are not covered by the reciprocal fishing license agreement. More information can be found in this years fishing regulations under reciprocal agreement with South Carolina.

The Savannah River basin had above average rainfall and corresponding flows in 2005. Catch rates during fall 2005 standardized were good for all species. One species that did quite well this year was the redbreast sunfish. Look for some nice size redbreasts to be caught this spring as this strong year-class grows to maturity. Panfish are concentrated in oxbows and around heavy structure in the form of river flow diverter pilings. Big redear sunfish are often found around sand bars in 2-4 feet of water. Try fishing small screw-tail jigs in these areas. The numbers of redear are not large, but their size and condition are excellent.

Largemouth bass continue to do well in the Savannah River. Look for good bass fishing this spring as water temperatures begin to rise and water levels begin to fall. Concentrate your fishing effort near creek mouths and around heavy structure. The largemouth bite starts to improve in February as fish prepare to spawn.

The majority of catfish are white catfish. Most catfish that are over 5 lbs. are channel catfish. Catfish spend most of their time in deep swift-flowing water along the last third of an outside bend. Catfish are more active at night and will often move out of these daytime hiding places into shallower water to feed. Try fishing these outside bend areas during the day with live bait and when darkness approaches, fish on shallow bars and flats where baitfish congregate.

The season for taking striped bass in the Savannah River is now back open! Anglers may harvest two striped bass per day over 27 inches in length. Striped bass numbers have rebounded sharply thanks to WRD's stocking program that began in the early 90's. It is important for anglers to realize that most of the stripers that they catch are stocked and that the number of naturally reproduced striped bass remains low. Twenty-pound striped bass are not uncommon and we are now starting to see the occasional 40-pounder in our samples! Is the state record of 63 pounds in danger?

St. Marys River

As with most of the other southeastern rivers, high water levels over the last three years have benefited the St. Marys River fish populations. Redbreast sunfish are not as numerous as in the Satilla River; however, the chances of catching fish 6 inches or larger are excellent. Fishing methods used on the Satilla River also work well on the St. Marys. Crickets and worms are good baits. Small lures, such as beetle-spins, work well when the water warms. If you are looking for a wilderness fishing experience and do not mind camping on the river bank for a night or two, try launching a canoe or small john boat at the St. George Landing and floating downstream approximately 30 miles to Traders Hill. This section of river has some excellent redbreast fishing.

The St. Marys River also supports a healthy bluegill population and catching bluegill weighing ¾ lb. or larger should be fairly common this year. The better bream fishing can be found in the lower half of the St. Marys River, from the Trader's Hill Recreational Area downstream. Using worms or crickets around cover in the creeks and oxbows of the lower river are your best bets for catching a stringer of bluegill.

The St. Marys River is considered to be a trophy bass river by some anglers. Although bass are not as plentiful as in other rivers, anglers frequently land wall-hangers. The better bass fishing can be found in the Kings Ferry area of the lower river. Try casting spinner baits and pitching jigs or worms around heavy cover in current breaks or backwater areas.

The St. Marys River is one of the few coastal plain rivers in southeast Georgia that has not been colonized by flathead catfish. Anglers are urged not to release this, or any other fish, into the St. Marys River unless it was caught there. Moving fish from one water body to another is illegal, and can have profound harmful effects on native fish populations.

Suwannee River

The 33-mile portion of the Suwannee River in Georgia offers a unique fishing experience. The dark "tea-stained" waters contain several different species than most anglers are used to pursuing. Chain pickerel, warmouth, flier and bullheads (catfish) are the main components of the catch. Due to the highly acidic waters, the river offers little in the way of bass, bluegill, redbreast sunfish or channel catfish angling.

As with the other southeastern rivers, fish populations in this portion of the Suwannee improved due to the presence of high water levels. Anglers should see good numbers of pickerel on the end of their line in 2006. Shallow running crankbaits like the Rapala Minnow or Rooster Tail are particularly effective on chain pickerel (jackfish). Jointed, colorful lures with their increased action also work well.

Warmouth should be very abundant in 2006. With the high water, these fish should have excellent growth rates and anglers should put good numbers of warmouth in the frying pan this year. Warmouth fishing should peak in late April and May. They are distributed throughout the river with a slight increase in number as you travel downstream to Fargo. Live crawfish are the favorite bait among anglers who target warmouth.

Flier can be caught year round in the upper reaches of the Suwannee River near the Okefenokee Swamp. As with the other species in the Suwannee, flier abundance rebounded due to high water conditions that have been present over the last three years. Setting the hook on a flier should be very common in 2006. Anglers targeting flier should concentrate their efforts in sloughs and backwater areas. The "yellow sallie" is the favorite artificial bait among flier anglers.

Bullhead fishing has been excellent the last few years and this should continue in 2006. Bullheads can be caught using worms, chicken livers, dead shrimp, and crickets off the bottom in deep water along the bank edges.

Toccoa River (Below Blue Ridge Dam)

Below Blue Ridge Reservoir, in Fannin County Georgia, lies the cold, clear water of the lower Toccoa River. Flowing approximately 18 miles through scenic north Georgia and southeast Tennessee, the Toccoa offers anglers perhaps some of the best year-round trout fishing in the state. Water flow in this tailrace fishery is greatly influenced by operations at Blue Ridge dam. Since water flows can become treacherous rapidly, fisherman should check TVA's daily generation schedules for the dam before heading out on the river. The river is floatable by canoe, tube or small boat, and wadeable at a number of locales. Popular access points include the park immediately below the dam, several road crossings, a TVA public access point downstream of Curtis Switch Rd., Horseshoe Bend Park and a concrete boat ramp in McCaysville, Georgia.

Trout account for nearly 75 percent of the game fish population of the lower Toccoa River. The WRD stocks the Toccoa annually with rainbow and brown trout adults and fingerlings. However, this is anything but your typical "stocker" trout stream. The system supports some natural reproduction and trout survive year-round in the river and its tributaries. These wild and holdover fish offer anglers trout exhibiting more natural behavior and finer table fare; an attribute often lost on "stockers". Trout of both species average around 9 inches, but plenty of 12-16 inch fish and an occasional 20+ inch bruiser can be hooked in the river. Trout can be taken with spinners, live bait and flies throughout the river. Fly-fisherman have come to find the lower

Toccoa as a dry fly enthusiasts dream, but wet flies and streamers have their place, especially in the winter months.

Checking TVA water release schedules for Blue Ridge Dam is not only a need for safety, but also a necessity of the resourceful angler. Water release not only affects river flow, but trout feeding times as well. Both browns and "bows" actively feed on falling water levels. That is to say, wet your line for hungry trout as the waters of the Toccoa drop at the tail end of a daily water release. Anglers "leapfrogging" from access point to access point on the river can sometimes keep up with these falling water conditions extending this golden fishing time. Feeding slows during low flow periods requiring stealthy and skilled lure presentation to score regular hook-ups.

Besides trout, the lower Toccoa is home to smallmouth, largemouth, spotted and rock bass, yellow perch, bream and even a few catfish. Generally, abundance of these other species is low, but nonetheless they provide anglers with different fishing opportunities. Anglers are encouraged to harvest their limit of spotted bass in 2006. Spots compete with, and can hybridize with, smallmouth bass, resulting in the collapse of the smallmouth fishery as has occurred in other areas of Georgia. Harvesting spots will help reduce competition with smallmouth and help sustain a unique Georgia fishery for years to come.

www.gofishgeorgia.com

Other Publications available from the
WRD Fisheries Management Section
(in both hard copy and online):

2006 Georgia Reservoir Fishing Prospects

Trout Streams of Georgia (map)

Introduction to Georgia Trout Fishing

Guidelines for Eating Fish from Georgia Waters

2006-2007 Sport Fishing Regulations

(GPC 1972)

section 2.4

V-001

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Hall, et al. 1991

V-532

Movements and Habitats of Shortnose Sturgeon, *Acipenser brevirostrum* in the Savannah River

J. Wayne Hall, Theodore I. J. Smith, and Scott D. Lamprecht

Telemetry studies were conducted to determine seasonal movements and habitat areas of adult and juvenile shortnose sturgeon (*Acipenser brevirostrum*) in the Savannah River. Thirty-two adults (19 prespawn and 13 postspawn) and six cultured juveniles were equipped with transmitters between April 1985 and March 1987. Upriver spawning migrations occurred from mid-February to mid-March when river temperatures ranged from 9 C to 12 C. Downstream migrations began in mid-March with all adult shortnosed sturgeon leaving the freshwater reaches by early May. Migration rates were as high as 33 km per day. Based on our observations, two probable spawning sites were identified: rkm 179–190 and rkm 275–278. These areas were characterized by submerged timber, scoured sand, and a clay and gravel substrate. Depths ranged from 6–9 m and bottom velocities averaged 82 cm/sec. The freshwater/saltwater boundary region of the river was utilized by adult and juvenile sturgeon during both fall and winter, and preliminary data suggest that this area may serve as an important feeding ground for sturgeon. A probable nursery area for juvenile shortnose and Atlantic sturgeon was identified, approximately 2–5 km downriver of the freshwater/saltwater boundary region. This area was characterized by sandy-mud and clay-mud bottom at a depth of 10–14 m.

Although formerly commercially harvested, the shortnose sturgeon, *Acipenser brevirostrum*, is listed currently as an endangered species in the United States (Miller, 1972) and is considered rare and possibly endangered in Canada (Gorham and McAllister, 1974). This species occurs along the east coast of North America from the Saint John River in New Brunswick, Canada to the St. Johns River in Florida (Vladykov and Greeley, 1963).

Little information exists on the biology and exploitation of this species which was part of the reason for listing the shortnose sturgeon as an endangered species in 1967. In recent years, however, research has been focused on this species, especially in the northeastern United States. Reproducing populations have been identified and characterized in the Delaware River, New Jersey (O'Herron and Able, New Jersey Division Fish, Game, and Wildlife, unpubl.), the Connecticut River, Massachusetts (Taubert, 1980; Buckley and Kynard, 1985), the Saint Johns River, New Brunswick, Canada (Dadswell, 1979), the Kennebec River, Maine (Squiers et al., Maine Department of Marine Resources, unpubl.), and Montsweag Bay, Maine (McCleave et al., 1977). Shortnose sturgeon have been documented in southern rivers: the Altamaha and Ogeechee rivers, Georgia (Heidt and Gilbert, 1979); the Savannah River, Georgia (Smith, unpubl.); the Winyah Bay System and the Pee Dee and Edisto rivers, South Carolina (Dadswell et al., NOAA, unpubl.; Smith and Dingley, 1984); in North Carolina (Seehorn, 1975); and Florida (Kilby et al., 1959); but little is known of its life history and ecology in southern rivers.

During April 1985 to March 1987, the South Carolina Wildlife and Marine Resources Division conducted studies focused on shortnose sturgeon in the Savannah River. Specific objectives were to characterize movements and habitats.

Study Area

The Savannah River basin drains an area of over 27 thousand ~~million~~ km². Its headwaters originate in the Blue Ridge Mountains of North Carolina, South Carolina, and Georgia. The Seneca and Tugaloo rivers join near Hartwell, Georgia, to form the Savannah River. From here, the river flows approximately 500 km in a southeasterly direction to the Atlantic Ocean (Fig. 1). The Savannah River serves as a boundary between South Carolina and Georgia.

The river is used for a variety of purposes ranging from cooling water disposal to com-

River. Detailed ecological analyses of the areas inhabited by sturgeon could provide additional information about the habitat requirements of both Atlantic and shortnose sturgeon. Rigorous examination of the freshwater/saltwater region and the characteristics of the King's Island Turning Basin could identify the importance of these areas in the life cycle of the Atlantic and shortnose sturgeon inhabiting the Savannah River.

Our data indicate that Savannah River sturgeon utilize much of the river during spawning migrations and make extensive use of the upper estuary. Careful consideration of possible impacts to the sturgeon population should be made before physically modifying the river channel or the water quality standards in the Savannah River.

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SRS Ecology
Environmental Information Document

V-533

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Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

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Haro, et al. 2000

Population Decline of the American Eel:

Implications for Research and Management

By Alex Haro, William Richkus, Kevin Whalen, Alex Hoar, W.-Dieter Busch, Sandra Lary, Tim Brush, and Douglas Dixon

V-534

ABSTRACT

We present evidence for a decline in the population of the American eel (*Anguilla rostrata*) from several widely distributed regions of North America from 1984 to 1995. Trends in population indices from commercial catch data, upstream passage counts, and seine, trawl, and electrofishing surveys were analyzed and found to be either not significant or significantly negative. Explanations for this decline, whether natural or anthropogenic, are unknown, due to variation and incompleteness in abundance data, and incomplete knowledge of eel life history, ecology, and population dynamics. A number of potential factors may be contributing to the decline, including (in alphabetical order): barriers to migration, habitat loss and alteration, hydro turbine mortality, oceanic conditions, overfishing, parasitism, and pollution. The paucity of life table data associated with the unconventional life history characteristics of anguillid eels (catadromy, panmixis, semelparity, high age at maturity, wide geographic distribution, and ecological generalist habit) prevents development of accurate population models and determination of overall effects influencing production and recruitment for this species. Historically there has been little attention to management of this species. A new coastwide management initiative by the Atlantic States Marine Fisheries Commission has taken a conservative approach to limiting controllable and anthropogenic sources of mortality and enhancing recruitment and restoration of available habitat. Objectives of the plan include: improving knowledge of eel utilization through better reporting of harvest, increasing knowledge of eel population dynamics and life history, providing migratory passage and access to historic eel freshwater habitat, and monitoring of abundance levels of various eel life stages.

Introduction

Anguillid eels (Genus *Anguilla*) are a widely distributed group of species that are of ecological importance in many tropical, subtropical, and temperate ecosystems. The American (*A. rostrata*), European (*A. anguilla*), and Japanese (*A. japonica*) eel have also supported important commercial fisheries throughout their ranges, and some species are of cultural significance in many countries. Within freshwater and coastal environments, eels are ecological generalists, having a wide distribution in variety of habitats, and comprise the primary fish biomass in some freshwater systems (Helfman et al. 1987). Growth of eels is slow compared to other fishes, and sexual maturity is not reached until an age of at least five and often in excess of 20 years for females (Jessop 1987). Male and female eels are also sexually dimorphic with respect to growth rate, and age and body mass at maturity (Oliveira 1999), with females generally growing faster and emigrating from freshwater at a greater size and age than males. All anguillid eels are semelparous and die after spawning; mortality at most life stages is consequently prereproductive mortality. The unconventional life history of anguillid eels, coupled with their high age at maturity, ecological generalist habit, and wide dispersal of juveniles makes these species unique from a conservation and management perspective.

All anguillid eels are catadromous, spawning at sea and migrating to coastal and freshwater environments

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The
Conservation and Restoration of the Robust Redhorse
Moxostoma robustum

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This report was based on the work of many individuals and organizations that form the Robust Redhorse Conservation Committee. The author has attempted to identify cooperating organizations, but not necessarily individuals, where appropriate within the body of this report. Special thanks are due to the hatchery managers and personnel that contributed to the successful culture of robust redhorse, and also to the organizations that provided funding, services, and materials. The author also thanks the individuals that provided helpful comments and suggestions on a draft of this report.

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1. INTRODUCTION

This report is the third report in a series of bi-annual reports required by the FERC license for Georgia Power Company's (GPC) Sinclair Hydroelectric Project (FERC No. 1951). The new license for the Sinclair Project, issued by the FERC on 19 March 1996 (effective date 1 May 1996), required the submission of a report every two years to the FERC. The license stated these reports should document the status of the robust redhorse and provide a determination regarding the adequacy of flow releases in meeting the needs of the robust redhorse.

The original report, titled *Conservation and Restoration of the Robust Redhorse, Volume 1*, was submitted to the FERC in June 1998. Because conservation activities had begun prior to the issuance of the Sinclair license, *Volume 1* presented detailed information about the rediscovery of the robust redhorse in 1991, the formation of the Robust Redhorse Conservation Committee (RRCC) in 1995, and other significant activities that occurred through April 1998. The second bi-annual report, titled *Conservation and Restoration of the Robust Redhorse, Volume2,* was submitted to the FERC in April 2000 and was limited to conservation activities that occurred from June 1998 through April 2000.

This report is limited primarily to activities that occurred between June 2000 and April 2002. When appropriate, some information on currently planned activities is presented. The format generally follows that of the previous reports. However, this report does not contain as much detail and discussion of research projects and results as did Volumes 1 and 2. This is because there are several other, more thorough and detailed reports available from the RRCC and their website, www.robustredhorse.com.

The material for this report was gathered from a multitude of sources, including complete and incomplete project reports, RRCC updates, letters, personal communications, and oral presentations. Some basic background information initially presented in previous reports has been included for readers that may be unfamiliar with the robust redhorse or its conservation.

1.1 Sinclair Hydroelectric Project

Sinclair Dam, a 45 megawatt hydroelectric project owned and operated by GPC, was completed in 1952 on the Oconee River near Milledgeville, GA. The dam forms the 15,330 acre Lake Sinclair, a popular fishing and recreation destination in central Georgia (Figure 1). The Sinclair Project is primarily used to provide generation capacity during peak demand periods, and it serves as the lower reservoir for Georgia Power's Wallace Dam pumped storage project.

During the early stages of FERC relicensing in 1991, a rare fish was "rediscovered" in the Oconee River downstream of the Sinclair Project. The fish was eventually identified as the robust redhorse *Moxostoma robustum* by several icthyologists.

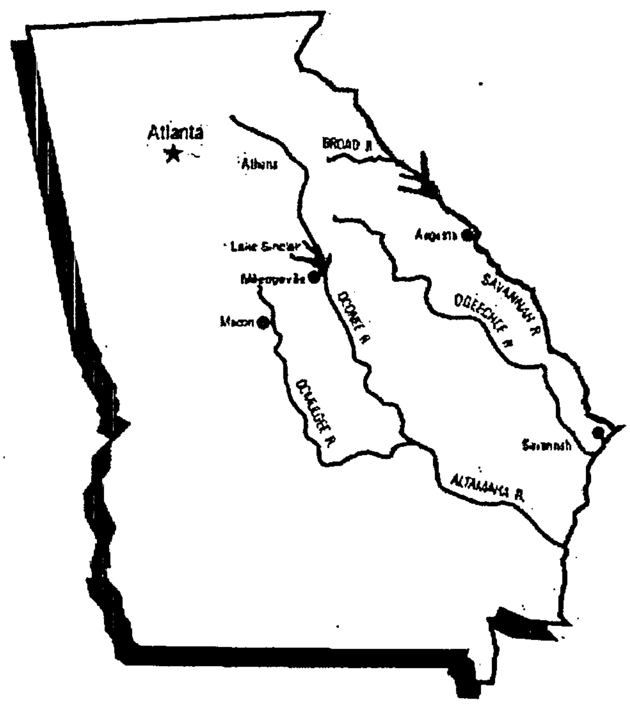

Figure 1. State of Georgia showing the location of GPC's Sinclair Hydroelectric Project and major rivers within the Georgia portion of the historic range for the robust redhorse.

1.2 Robust Redhorse *Moxostoma robustum*

The robust redhorse was originally described in 1870 by master naturalist Edward Cope from specimens collected in the Yadkin River, NC. Unfortunately, Cope's original specimens were lost, and labels were mistakenly applied to another species. During the next 100 years or so, the real robust redhorse was known by only two specimens, collected from the Savannah River, Georgia / South Carolina in 1980 and from the Pee Dee River, North Carolina in 1985. The two existing specimens were believed to belong to an undescribed species of redhorse. The discovery of the Oconee River population of robust redhorse helped to unravel the history of this species.

That discovery occurred in August 1991, when biologists with the Georgia Department of Natural Resources (GDNR) collected five large, unrecognized suckers from the Oconee River downstream of Sinclair Dam. Several well-known ichthyologists including Dr. Henry Bart (then curator of the Auburn University fish collection), Dr. Byron Freeman, curator of the University of Georgia fish collection, and Dr. Robert Jenkins of Roanoke College, Virginia, worked to unravel the mystery. They concluded the five specimens from the Oconee River were the same species as the two existing specimens that had been collected in 1980 and 1985. They further concluded that all specimens belonged to the species originally described by Cope in 1870. The currently accepted historic range consists of southeastern Atlantic slope rivers, extending from at least the Altamaha River system in Georgia to at least the Pee Dee River system in North and South Carolina.

Subsequent reviews of available information by many agencies and individuals suggested that conservation and restoration actions should begin immediately for this species. Part of the concern centered on the lack of other records for the species, which potentially indicated that a sole remnant population had been rediscovered in the Oconee River. Another issue was that fish collections from the Oconee River were comprised primarily of larger individuals, prompting concerns about a senescing population or some other problems that might be affecting recruitment of robust redhorse. These potential problems included, but are not limited to, artificial flows from power generation, erosion and siltation, and introduced predatory species such as flathead catfish.

2. ADMINISTRATIVE ACTIVITIES

2.1 Robust Redhorse Conservation Committee

The Robust Redhorse Conservation Committee (RRCC) was formed by the signing of a Memorandum of Understanding (MOU) in 1995. The RRCC was designed as a stakeholder partnership to restore the robust redhorse throughout its former range. The primary goals of the RRCC are to implement research and conservation measures, enhance recruitment in the existing Oconee River population, and re-establish robust redhorse populations in appropriate river systems within the species' former range.

The RRCC is the overall vehicle directing recovery of the robust redhorse, and has determined priority avenues for necessary research and action. Through formal annual meetings and innumerable informal meetings among members and other interested parties, the RRCC has identified impediments to the recovery effort, conducted research related to those impediments, and formulated solutions and implemented conservation actions. The RRCC has also been very effective in publicizing the recovery effort. As originally intended, the RRCC has been the driving force behind the conservation and restoration of the robust redhorse.

Elections

Ms. Terry DeMeo of the University of Georgia (UGA), Institute of Government, was approved by the RRCC as the 3rd Chair of the Committee at the October 1999 meeting. Her term began in October 2000 as she succeeded Scott Hendricks of Georgia Power Company as the Chair of the RRCC. Her term will expire in October 2002.

Mr. Greg Looney of the U.S. Fish and Wildlife Service was approved by the RRCC as the 4th Chair of the Committee at the October 2001 meeting. Mr. Looney is serving as the Chair-elect until the October 2002 meeting when his term as Chair will begin. His term will expire in October 2004.

Technical Advisory Group

The Technical Advisory Group (TAG) is a small group of individuals representing several RRCC member organizations. The TAG handles the bulk of the daily activities related to the conservation of robust redhorse and attempts to gather information and make recommendations to the RRCC as necessary. As the conservation effort has expanded, the RRCC has tried to add key individuals to this group.

The RRCC recognized that changes are needed in the way decisions are made and in the overall administration of the conservation program. The TAG is currently drafting several components of a 'policy framework,' with guidance on several difficult issues that should facilitate timely and effective decisions within the RRCC. This exercise should also help the RRCC develop meaningful recommendations for state and federal natural resources agencies as the conservation effort continues to expand across state lines and jurisdictional boundaries.

In addition, the RRCC recognizes that there may be a need to modify and formalize its organization. The author of this report envisions an organization that eventually looks and functions very much like a professional society. This organizational structure may inclue an Executive Committee, led by the Chair, as the primary authority within the RRCC. The current positions for Chair-elect and Project Manager would likely continue to be critical components of the organization. This is not substantially different from the way the RRCC currently functions, however there is a perceived need to clearly designate authority and decision making processes.

Other committees would be established to deal with specific issues or geographical areas as necessary. For example, the recent expansion into the Carolinas and the discovery of robust redhorse in the Pee Dee River, NC/SC has prompted interest in forming a 'Yadkin-Pee Dee Working Group' or similarly named sub-committee to the RRCC. An initial meeting to explore options for such a group was very well attended by natural resource agencies and private utilities in the Carolinas. A charter for this group was drafted by John Crutchfield of Carolina Power and Light and is currently under review by the TAG.

Robust Redhorse Conservation Strategy

The original MOU formed the RRCC and provided some general goals, but did not offer details for implementing the conservation effort. The RRCC saw the need to develop an overall guidance document, or roadmap for the project. An initial version of the Robust Redhorse Conservation Strategy, drafted by Mike Nichols of Georgia Power Company, was reviewed by the RRCC member organizations. The Strategy was subsequently approved in March 2000 by Scott Hendricks, then Chair of the RRCC.

The Strategy describes the extent of current knowledge of robust redhorse and its distribution, discusses problems facing the species, and lists specific goals and objectives for robust redhorse conservation throughout its historic range. The Strategy also outlines procedures and actions believed necessary to reach those conservation goals and objectives. The Strategy is intended to be a flexible document and the RRCC may revise the Strategy as new information becomes available.

The Strategy has recently been updated with new information, and will likely be expanded to include some of the RRCC policy and guidance information discussed above. A revised version of the Conservation Strategy has been distributed to several RRCC members for comment. It is expected that the Conservation Strategy would then be approved by the Chair after presentation to the RRCC.

Candidate Conservation Agreement With Assurances

One of the primary stated goals for the RRCC is to create additional populations of robust redhorse by introducing the species to rivers within its historic range. In many cases, reintroduction can be successfully accomplished without incident. However, the RRCC recognized that reintroducing an imperiled species could potentially create local problems and negative publicity. In these cases, the RRCC needed a sound approach for effectively handling one of the most critical components of the conservation effort.

One type of approach may be through the use of Candidate Conservation Agreements with Assurances (CCAA). The Final Policy for CCAAs was published by the USFWS in 1999 (64 Federal Register 32726-32736 and 50 C.F.R. §§ 13 and 17). Essentially, CCAAs are meant to promote conservation actions by encouraging partnerships between private entities and state and federal natural resources agencies. Voluntary participants in such agreements may receive assurances from the USFWS that limit risk, should the target species of that agreement become listed under the Endangered Species Act (ESA).

The Ocmulgee River (Figure 1), a candidate site for reintroduction, provided an opportunity for some members of the RRCC to apply the CCAA policy. The upper reaches of the Ocmulgee River are influenced by generation from GPC's Lloyd Shoals Hydroelectric facility, which recently completed FERC relicensing. During relicensing, minimum flow was increased to enhance aquatic habitat, and a labyrinth weir was constructed to improve dissolved oxygen concentrations in the river.

GPC has invested considerable time and dollars on environmental enhancements to the upper Ocmulgee River and believes these enhancements should also benefit any potential robust redhorse population. However, GPC also believed that a reintroduction of robust redhorse potentially represented some unacceptable level of risk to the Lloyd Shoals facility, if the species was ever federally listed under the ESA. GPC expressed these concerns to GDNR and the USFWS, and discussions began that ultimately led to a CCAA for the robust redhorse.

Under the CCAA, GPC volunteered to participate in the reintroduction and provide funding for some critical telemetry studies on the reintroduced fish. GPC also agreed to some population monitoring and reporting. In return, GPC received assurances that if the robust redhorse is ever listed under the ESA, and the CCAA has been implemented in good faith by GPC, the USFWS will not require additional land, water, or resource restrictions beyond those that GPC voluntarily committed to under the terms of the original agreement. These assurances include the preservation of the flow regime described in the current FERC license for the Lloyd Shoals Project which expires in 2023. The assurances will be provided through an Enhancement of Survival Permit which will take effect if and when the robust redhorse is federally listed under the ESA.

This CCAA is important because it provides additional conservation actions for the robust redhorse while providing some regulatory certainty and operational flexibility to GPC. However, the CCAA might be more important to the overall conservation effort because it provides a working example of how potential reintroductions, or other problems, could be avoided and turned into a positive cooperative effort to benefit the species. It is believed that this CCAA for the robust redhorse was the second CCAA implemented in the U.S. It was also the first CCAA to involve an aquatic species and a private company.

Robust Redhorse Video

An excellent video that describes the conservation effort for the robust redhorse by the RRCC was completed in 2001. This video was produced by the GDNR and is suitable for a half-hour feature on public television. Several RRCC members contributed funding for the development of this video, which has won at least one national award.

2.2 Flow Advisory Team for the Oconee River

The Flow Advisory Team for the Oconee River (Advisory Team) functions under the overall umbrella of the RRCC with some shared memberships and administration. The current members of the Advisory Team are the GDNR, USFWS, U.S. Geological Survey, Biological Resources Division (USGS-BRD), Georgia Wildlife Federation, and GPC. The primary responsibilities of the Advisory Team are to monitor the effectiveness of the negotiated flows for the Sinclair Project for the robust redhorse in the Oconee River. The agreement provides that the Advisory Team may review flow data from the Oconee River, studies developed by the RRCC, and other pertinent information related to the robust redhorse to help determine if any changes to the negotiated flow agreement are necessary. If studies suggest that flow changes are needed for the Oconee River to improve habitat for the robust redhorse, the Advisory Team may petition the FERC, under consensus of members, with its recommendations. These recommendations would then be subject to appropriate FERC evaluation and approval.

Negotiated Flow Agreement

A negotiated flow agreement was finalized in 1995 prior to the submittal of the license application for the Sinclair Project. The negotiated flow agreement, outlined in Table 1 below, was designed primarily to enhance reproductive success of the robust redhorse. Specifically, the flow agreement provides: 1) significant increases in minimum flows throughout the year, 2) a significant increase in flow stability throughout the year, and 3) run-of-river flows during spawning and early rearing periods for robust redhorse. Although primarily directed at robust redhorse, anadromous species were also considered during the formation of the flow agreement.

Table 1. Negotiated flow agreement for Sinclair Hydroelectric Project.

MONTH	FLOW	OPERATION
Dec - Feb	500 cfs minimum	normal peaking
Mar - Apr	1500 cfs minimum	modified peaking(A)
May	run-of-river	
Jun(B) – Nov	700 cfs minimum	normal peaking

A - modified peaking refers to the number of units (1 or 2) to be utilized depending on the amount of inflow to the reservoir
B - From June 1 -10, units will be operated run-of-river unless electric system demands necessitate normal peaking operation
The agreement also provided for an increase in generation scheduling from 5 to 7 days per week. This was done to reduce the extended low flow periods that previously resulted from little weekend generation.

Flow Suitability

Although finalized early in 1995, the flow agreement for the Oconee River was not implemented until June 1996, as requested by the RRCC. This request was made to allow the RRCC to collect two years of baseline data for comparison with data collected after implementation of the new flow regime. Consequently, 1997 was the first year of data collection under the new flow agreement. However, the extreme hydrological variability, combined with the low numbers of the larval robust redhorse collected, have complicated the interpretation of these data and fair evaluation of the flow agreement. For example, the winter of 1997 through the spring of 1998 was influenced by the weather phenomena known as El Nino. Heavy rains, high discharges and river levels were common throughout the spring. This was immediately followed by severe drought (La Nina) that extended through at least 2001.

After several years of data collection under the new flow regime, the Flow Advisory Team met formally in August of 2001 to discuss the data and suitability of flows. Attending the meeting were: Mark Bowers–USFWS; Chris Skelton–GDNR; Dr. Carl Quertermus–GA Wildlife Federation; Mike Wilder–GPC; Jimmy Evans–GDNR; Mike Nichols–GPC; Dr. Cecil Jennings–USGS/UGA Coop Fish and Wildlife Research Unit; Greg Looney–USFWS; Dr. Bud Freeman–UGA Institute of Ecology; Scott Hendricks–GPC.

Scott Hendricks presented an overview of the Sinclair license articles regarding the robust redhorse and the responsibilities of the Advisory Team. One order of business was to elect a Chairman for the Advisory Team. The members present elected Scott Hendricks as Chairman of the Advisory Team.

The group then discussed available data from the Oconee River and its implications for robust redhorse. There was discussion of recent laboratory studies of temperature and flow effects on egg and larval survival, and that high water temperatures could limit survival. There was also discussion about how river temperatures could potentially be influenced by the Sinclair flow regime and also about the highly variable hydrologic conditions in the Oconee basin during the last several years. Some members expressed concern that manipulating flows from Sinclair Dam in May for broodfish collection (as opposed to run-of-river flows) could also result in a temperature rise.

The relationships between temperature, flow regime, and reproductive success in the river are unclear, and there was discussion about the lack of temperature data available. GPC volunteered to install temperature monitors at four locations in the Oconee River in March 2002. GPC also plans to maintain these monitors for several years during the spring months. It is expected that this information will help us better understand the environmental cues governing the spawning time for robust redhorse in the Oconee River, which in turn will enhance efficiency of broodfish collection and propagation efforts. This information should also compliment ongoing recruitment studies and help to define any potential relationships between the flow regime at Sinclair Dam and reproductive success of robust redhorse.

Although annual variability is high, larval abundance in recent years has generally increased in sampling targeted toward the early life stages. Catch rates of larvae and juveniles of many other species have also increased over previous years and there is substantial anecdotal evidence of improved sport fish abundance. The Advisory Team agreed that we did not yet have enough solid information to determine the adequacy of the new flow regime in meeting the needs of robust redhorse in the Oconee River. However, the Advisory Team did believe that there was evidence that indicated, at least preliminarily, that the new flow regime was having positive effects on reproduction and recruitment of many other species.

Electrofishing catch rates have declined during spring broodfish sampling on the Oconee River for the 1994 – 2001 period of record. The decline was most apparent during 1994 – 1997, but has generally stabilized at lower rates since 1998. Juvenile catch rates have been low for the period of record, but it is unclear if this is a reflection of actual abundance, a sampling bias resulting from adult vs. juvenile habitat partitioning, or some other factor. By contrast, estimates of adult population size have remained relatively stable during the 1995 – 2000 period for which these estimates are available.

It is difficult to separate the effects of the extreme hydrological conditions that have been experienced during the last several years of this project from the effects of the new flow regime. At this point the direct and potentially indirect relationship between flows from Sinclair Dam and the robust redhorse is unclear. The general opinion of the Advisory Team is that the evidence provided by current research and monitoring of robust redhorse does not indicate that a modification of the current flow agreement is necessary.

3. CONSERVATION STATUS OF ROBUST REDHORSE

3.1 Oconee River Population

Much of the information on the status of the Oconee River population has been based on electrofishing catch during spring broodfish collection during 1994 - 2001. These data appear to indicate a decline in electrofishing catch rates, although catch rates were similar during the last five years. The data also show a very general shift in the length frequency of the catch toward larger individuals, which may suggest an aging population. Very few juveniles and no young-of-year have been sampled during broodfish collection or other studies on the Oconee River. The large mean length of captured individuals, and the apparent lack of juvenile fish suggests low recruitment rates of robust redhorse within the last decade or two.

During most years one or two juvenile fish, measuring around 420 – 480 mm, have been captured during broodfish collection. This indicates there is at least some recruitment occurring, but how much recruitment is necessary to maintain a viable population of this long-lived species in the Oconee River is unknown. During 2000 and 2001, catch rates of adult fish were similar to several previous years, but the abundance of juveniles and small adults (420 –560 mm) increased. There was also a slight shift in the length frequency to smaller individuals. The shift in average size is likely a cumulative effect of these younger individuals showing up in the catch. Several of the juveniles and small adults captured in 2000 and 2001 were stocked fish (see below).

The repeated appearance of wild robust redhorse near 420 mm indicates that individuals less than 420 mm do exist in the Oconee River system. The minimum size of stocked fish that have been recaptured in other systems, with electrofishing gear, has also been around 400 mm. This fact is puzzling because robust redhorse substantially less than 420 mm can be collected from ponds with electrofishing gear, indicating this size should also be vulnerable to electrofishing gear in natural habitats. Small specimens of other sucker species have also been collected from rivers containing robust redhorse, yet the smaller robust redhorse have not been collected.

Small numbers of juvenile robust redhorse (213) have been stocked into the Oconee River as part of telemetry studies and other efforts to improve understanding of habitat utilization of early life stages. A few of these individuals have been recaptured during broodfish collection efforts. There are still many unknowns about the Oconee River population, but overall, it appears stable and there are reasons to be encouraged about its future. There is evidence that some recruitment is occurring, research projects are in place to help monitor reproductive and recruitment success, and the technology and ability exists to supplement the population with juveniles if the RRCC determines that supplementation is needed to ensure the long-term survival of this population.

3.2 Other Populations

For the first several years during the RRCC's existence, it was commonly thought that the Oconee River might contain the only remaining population of robust redhorse. This seemed reasonable, considering the extensive survey work on southeastern rivers. It also seemed unlikely that a fish as large as adult robust redhorse could be missed during sampling. However, habitats associated with adult robust redhorse in the Oconee River (swift, moderately deep waters with accumulations of woody debris) are difficult to sample effectively. The robust redhorse has also proven somewhat cryptic and difficult to collect even in pond environments.

The RRCC has organized intensive surveys on several rivers within the believed historic range of the robust redhorse and more are planned. Many of these surveys have documented other existing populations that are shown in Figure 2. This map, created by Dr. Robert Jenkins (Roanoke College, VA), Dr. Byron Freeman (UGA Institute of Ecology), and James Evans (GDNR), partially documents the large effort of the RRCC to increase knowledge and conservation actions for the robust redhorse throughout the historic range of the species.

<u>Savannah River, GA/SC</u>

Volume 2, submitted in April 2000, indicated that the Savannah River near and downstream of Augusta, GA was a high priority site because of the incidental collection of a single robust redhorse in October 1998. Subsequent surveys detected a population of unknown size near Augusta, GA. Other surveys and GDNR sampling have located robust redhorse at numerous locations between Augusta and U.S. Hwy 301. Spawning locations and spawning robust redhorse have been observed near Augusta.

Plans are being developed for a possible attempt at broodfish collection and propagation in early May 2002. It is expected that SCDNR may use these fish for introduction into the Broad River system, SC.

<u>Ocmulgee River, GA</u>

About 4,000 robust redhorse were stocked into the Ocmulgee River in February 2002 as the first step to establishing another wild population. These fish were from several year classes and were stocked at three locations between GPC's Lloyd Shoals Hydroelectric Project and a small, low-head dam at Juliette, GA. As discussed earlier, the implementation of the CCAA for the robust redhorse paved the way for this reintroduction.

The CCAA describes goals of the project, responsibilities of the parties to the agreement, provides a timeline and suggested measures of progress toward the goals of the reintroduction. Currently, two separate telemetry studies are underway to learn more about the species' dispersal following stocking, movement patterns and habitat preferences. A press release about this project is provided as Appendix A.

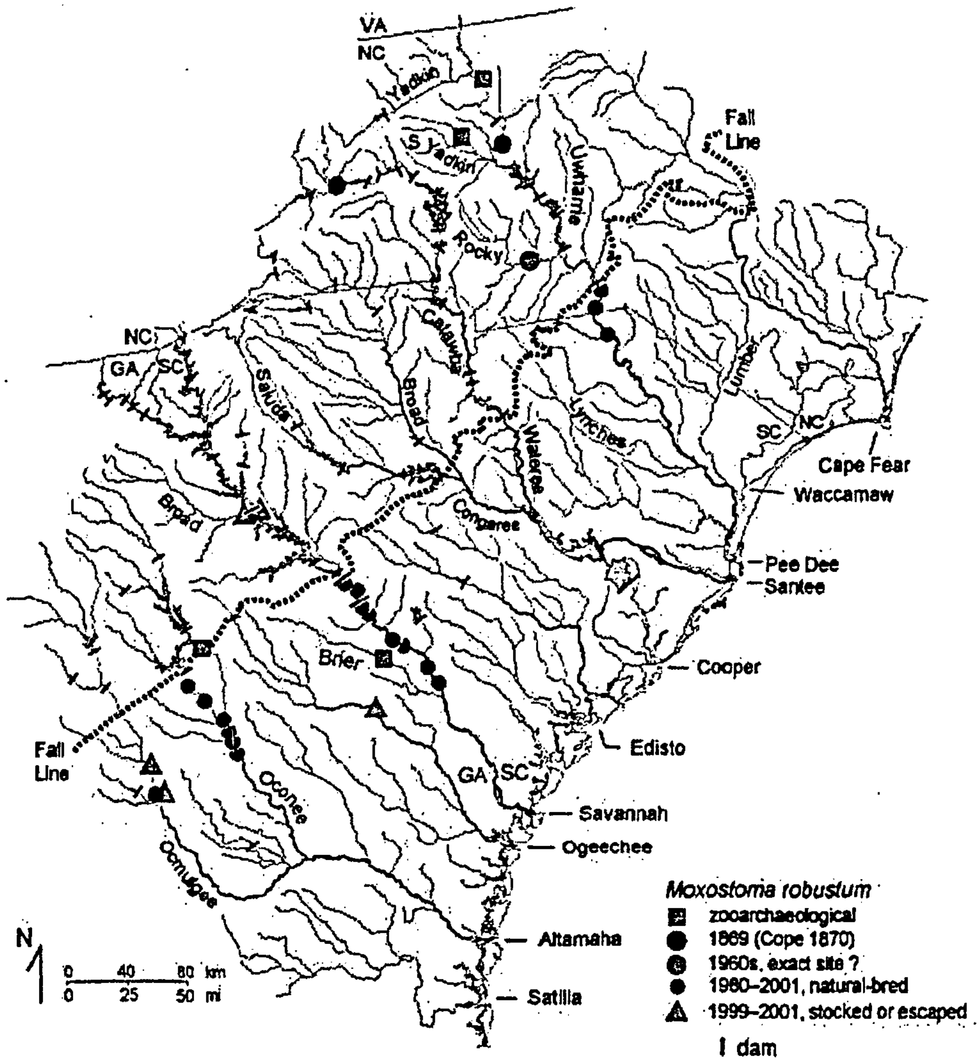

Fig. 00. Robust redhorse records of natural-bred fish (squares and circles); and of artificially-bred fish (triangles) captured after stocking or escape from rearing ponds. Dams shown mainly for larger streams (south of Cape Fear drainage). Savannah R. sites of the 4 record symbols crossed by dam symbols are below respective dams. Fall Line drawn from Anonymous (1963a–c) and Harris and Zullo (1991). Oconee R. detail in Fig. 00; hypothetical total range in Fig. 00.

Map by R. E. Jenkins, B. J. Freeman, and J. W. Evans (Dec 2001)

Figure 2. Robust redhorse records as of December 2001.

Pee Dee River, NC/SC

Volume 2, submitted in April 2000, indicated that a single, adult female robust redhorse had been captured from the Pee Dee River, near the site that produced the 1985 specimen. Surveys were also conducted during spring 2001 and two robust redhorse were captured. Additional surveys are scheduled for May 6-10, 2002. These surveys are large, multi-agency efforts that are specifically intended to detect robust redhorse if they exist in a river reach. As discussed above, a working group is currently being formed to address robust redhorse issues and conservation in the Yadkin/Pee Dee River basin. This group would continue to function under the umbrella of the RRCC.

3.3 Research Summary

Volumes 1 and 2 provided detailed summaries of most of the research that had been conducted during the previous years. Because detailed research summaries are contained in several other reports available from the RRCC, this report will only provide a short description of the research topics. The agenda from the 2001 annual meeting of the RRCC is attached as Appendix C to provide the reader a better idea of the full range of topics under consideration by the RRCC.

One of GPC's primary concerns is the relationship between flows at Sinclair Dam and the robust redhorse population in the Oconee River. For this reason, GPC continued to provide funding for reproduction and recruitment studies in the Oconee River to detect changes in reproductive success, telemetry studies to address movement patterns, and population modeling to address population size and long-term stability. GPC is also collecting temperature data from several locations in the Oconee River to help understand any potential relationships between river flow, temperature, and spawning and reproductive success.

In general, research has followed in a similar direction as previous years, building on information gained in initial projects. During the early years of robust redhorse conservation, the capture of broodfish and propagation techniques for fingerling production were primary research interests. As these techniques were developed, some of the focus shifted to enhancing growth, survival, and production in hatchery ponds. Management of genetics in hatchery produced fish also became an important topic as the RRCC realized that propagation and stocking was indeed a viable conservation option.

The conservation effort has advanced in both complexity and geographic scope, and the RRCC has observed long-term (several years) survival and good growth of introduced fish. This success, and a few incidental captures of native adult robust redhorse in previously sampled systems, highlighted the need to address potential concerns about mixing hatchery fish with wild populations. In response, the RRCC focused on intensive status surveys in several rivers in Georgia and the Carolinas to hopefully detect additional populations. Genetics research and characterization of these populations is an important topic because there are some genetic distinctions in robust redhorse populations from different river systems.

Balancing reintroduction and establishment of additional populations with genetic concerns is a primary issue for the RRCC. The RRCC has responded by inviting several genetics experts from around the U.S. to speak and participate in annual meetings, and to provide advice on this subject. Researchers have also examined genetics management in other conservation programs and provided reports and advice to the RRCC. The question of whether to manage for species or individual populations is highly controversial and is one that the RRCC has every intent of handling properly.

There is also much interest in habitat preferences and habitat conservation. The RRCC has directed research to identify important habitats and is exploring potential measures to maintain or enhance these habitats.

4. WHERE DO WE GO FROM HERE?

Much progress has been made toward the original goals of maintaining and enhancing the Oconee River population and identifying other existing populations. Robust redhorse fingerlings, produced with techniques developed by the RRCC, have been stocked in rivers to establish additional populations. In most cases, monitoring has indicated successful survival to at least several years of age.

Now that the RRCC is confident that robust redhorse can be introduced into the wild and survive, there are many new questions relating to these reintroduction efforts. One question is whether it is more efficient to stock young Phase I fingerlings or more advanced Phase II fish. Some believe that Phase II fish may be better able to survive the predation pressures of natural rivers and may offer a better chance of establishing populations. However, larger numbers of Phase I fish can be produced in a more timely fashion with less expense than Phase II. The RRCC is watching closely to see if these introduced fish will make spawning attempts, and if that spawning will be successful.

Other questions relate to reintroduction strategies, and identifying rivers or river reaches that should have high priority. The implementation of the CCAA should be a boost to conservation efforts as one example of how to successfully and positively deal with problematic issues and conservation actions that cross state and jurisdictional boundaries. Still other questions center around the overall function of the RRCC and how it should be structured to effectively manage the large and complex conservation effort that now exists. The appropriate management of genetics issues will also continue to be a priority for the RRCC.

Another difficult issue will be habitat management and possibly restoration. As we learn more about the population dynamics of robust redhorse and what types of habitat may be required for various life stages, it is anticipated that the RRCC will work to address habitat issues.

Overall, the Oconee River population appears stable, and still serves as a source of broodfish for fingerling production. Investigations into population dynamics, monitoring of reproduction and recruitment success, and assessments of habitat in relation to the new flow regime at Sinclair Dam continue. Additional populations have been located and created, which adds to the long-term stability of this species.

APPENDIX A

FOR IMMEDIATE RELEASE

LANDMARK AGREEMENT HEARLDS PROACTIVE CONSERVATION OF RARE FISH TO KEEP IT FROM BECOMING LISTED AS AN ENDANGERED SPECIES

Social Circle, Ga. (January 11, 2002) – A landmark conservation agreement has been signed that will improve the status of the robust redhorse by restoring this rare fish to the Ocmulgee River between Lloyd Shoals and Juliette dams in central Georgia. The Candidate Conservation Agreement with Assurances (CCAA) was developed as a collaborative effort among the U.S. Fish and Wildlife Service(Service), the Georgia Department of Natural Resources (DNR), and Georgia Power Company (Georgia Power) and is a new and innovative approach to restoring imperiled species.

"The completion of the CCAA and the stocking of robust redhorse in the Ocmulgee River marks a major milestone in the conservation efforts by restoring the fish to a section of the Ocmulgee River where it likely occurred historically," said David Waller, Director for the Georgia Department of Natural Resources, Wildlife Resources Division. "This historic event also signals significant progress in the voluntary, proactive conservation of an imperiled species."

This is the first CCAA to be implemented in the Southeast and only the second in the nation. It is also the first CCAA involving a private company and the first CCAA to be developed for an aquatic species. In return for taking specific conservation actions to recover the robust redhorse, Georgia Power Company will receive assurances regarding their obligations under the Endangered Species Act in the event that this species is listed in the future.

The robust redhorse, a large sucker only known from large rivers along the south Atlantic Coast, was initially described from the Yadkin River, North Carolina in 1869, but the species was believed to be extinct until it was rediscovered in the Oconee River in 1991. A small population was also discovered in the Ocmulgee River in the Houston/Twiggs County area in 1999.

The Robust Redhorse Conservation Committee including the Service, DNR, Georgia Power and other stakeholders has been working since 1995 to recover the fish. These efforts have included life history research, hatchery propagation using wild fish broodfish, and establishing new populations of the species in the Broad and Ogeechee Rivers. The CCAA continues these efforts by restoring the fish to a section of the Ocmulgee River.

According to Sam D. Hamilton, Southeast Regional Director, USFWS, these conservation actions should help prevent the need to list the robust redhorse under the Federal Endangered Species Act.

"This agreement highlights the cooperation of private industry, the state of Georgia and the Service to achieve conservation of a rare species so that the Endangered Species Act may never need come into play," said Hamilton. "We applaud the cooperative efforts of Georgia Power and the Georgia Department of Natural Resources, and their leadership in pursuing conservation for this unique part of Georgia's natural heritage."

In addition to the proposed reintroduction, this latest restoration effort will include surveys and monitoring to track the introduced fish and to evaluate the results of stocking.

For more information contact:
Robin Hill, Public Affairs Coordinator, (770) 918-6400
Noreen Walsh, USFWS, (404) 679-7085
Amoi Geter, Georgia Power Media Relations, (404) 506-7676

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APPENDIX B

ROBUST REDHORSE LITERATURE
Partial Listing of Literature of Interest**

Many of these publications were used as references for this report.

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Nichols, M.C. 1999. Conservation strategy for robust redhorse (*Moxostoma robustum*). Robust Redhorse Conservation Committee.

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<u>Popular Press</u>

"Mystery Fish" by Richard T. Bryant, James W. Evans, Robert E. Jenkins and Byron J. Freeman. Southern Wildlife. Volume 1, Number 2. 1996.

"A Splashy Comeback" by Stephen Sawicki. Animals. Winter 2002

APPENDIX C

AGENDA – 2001 ANNUAL MEETING**
ROBUST REDHORSE CONSERVATION COMMITTEE
South Carolina Aquarium - Charleston

OCTOBER 3, 2001

6:30 pm - Reception Tour of the South Carolina Aquarium and Robust Redhorse Exhibit

OCTOBER 4, 2001

8:00 am – Welcome and Introductions – Chris Andrews and Terry DeMeo
8:15 am – South Carolina Aquarium Robust Redhorse Exhibit and Educational Efforts – Chris Andrews, David Wilkins and Whit McMillan

Supplemental Breeding Program – 2001

8:30 am – Broodfish Collection on the Oconee River – Jimmy Evans
8:40 am – Spawning Results and Cryopreservation Update – Greg Looney
8:50 am – Fingerling Distribution and Fry Production – Jay Shelton

Habitat, Capture Rates and Population Dynamics

9:00 am – Evaluation of Spawning Aggregates, Oconee (Avants) and Savannah rivers – Bud Freeman
9:15 am – Database of Captures of Robust Redhorse, 1980-2001 – Bob Jenkins
9:35 am – Population Estimate of the Oconee River – Jimmy Evans
9:50 am – Reproduction and Recruitment Success in the Oconee River – Cecil Jennings
10:05 am – Flow Advisory Team Update – Scott Hendricks
10:15 am – **BREAK**

Continue Habitat, Capture Rates and Population Dynamics

10:30 am – Restoration Efforts for Razorback Sucker in the Upper Colorado River Basin – Tim Modde
10:50 am – Telemetry Evaluations – Cecil Jennings
11:05 am – Otolith Analysis and Habitat Use – Dave Coughlan
11:25 am – Discussion
12:00 pm – **LUNCH**

Hatchery Management

12:20 pm – Piedmont NWR Refugial Population – Greg Walmsley
12:35 pm – Central Georgia Branch Station Refugial Population – Jay Shelton
12:45 pm – Update on Hatchery Pond Culture Studies – Jay Shelton
1:00 pm – Discussion

Status Surveys

1:30 pm – Pee Dee River, NC Effort and Future Direction – John Crutchfield
1:40 pm – Broad River, SC – Ross Self
1:50 pm – Ocmulgee River, GA – Jimmy Evans
2:00 pm – Discussion

2:30 pm – **BREAK**

Genetics

2:45 pm – Razorback Sucker Genetics, Lessons Learned – Holt Williamson
3:05 pm – Molecular Approach to Identify Robust Redhorse Larvae – Isaac Wirgin
3:20 pm – Comparison of Mitochondrial DNA and Nuclear DNA Divergence Between Robust Redhorse and Silver Redhorse from Three Populations – Isaac Wirgin
3:40 pm – Genetic Sensitivity Analysis of Robust Redhorse Supplemental Breeding Program – Anthony Fiumera
4:00 pm – Discussion
5:00 pm – **ADJOURN**

6:30 pm – **Low Country Boil and Video Presentation:** *Chronology, Habitat and Behavior of Spawning of Redhorse Suckers, Genus Moxostoma*

October 5, 2001
8:00 am – **Commence**

Management of Robust Redhorse Through Re-introduction

8:15 am – Summary of Broad River Re-introduction – Bud Freeman
8:30 am – Update on the Ocmulgee River Conservation Agreement – Mike Nichols
8:45 am – Plans to Rear Broodfish and Stock the Broad River, SC – Ross Self
9:00 am – Stocking Scenario for Fall 2001 – Spring 2002 – Discussion

12:00 pm – **LUNCH**

Announcements
1:00 pm – Culture, Broodfish Collection, and Disease Protocols – Greg Looney
1:05 pm – Status of Grant for Robust Redhorse Genetics Workshop – Greg Looney
1:10 pm – Plans for Fish Passage Structures on the Savannah River – Mark Bowers
1:25 pm – Status of Video Distribution – Jimmy Evans
1:35 pm – Oconee River Bank Stabilization Project Update – Terry DeMeo
1:45 pm – Update on Greg's Replacement and Coordinator's Position – Terry DeMeo
1:50 pm – Presentation on the RRCC at the AZA National Meeting – Terry DeMeo
2:00 pm – Status of Remaining Work Items from the 2000 Meeting – Terry DeMeo

2:05 pm – **BREAK**

Business

2:20 pm – Establishment of a Carolina's Technical Advisory Group (TAG)
2:30 pm – Prioritize Research and Work Items for 2002
3:30 pm – Approval of Vice-Chairman Elect
3:40 pm – Location and Dates for 2002 Annual Meeting
4:00 pm – Wrap-Up
4:20 pm – **ADJOURN**

** Agenda provided by Terry DeMeo

Jenkins and Burkhead 1994

Freshwater Fishes of Virginia

Robert E. Jenkins and Noel M. Burkhead

Roanoke College
Salem, Virginia

With special thanks to William H. Haxo

American Fisheries Society
Bethesda, Maryland

FRESHWATER EELS

Family Anguillidae

The Anguillidae are a family of 15 species of true eels, all in the genus *Anguilla*, which occupy temperate and tropical portions of the Atlantic, western Pacific, and Indian oceans and their influents. The American eel *Anguilla rostrata* of the northwestern Atlantic basin is the only North American species. The species of *Anguilla* are catadromous and semelparous; they spend most of their life in fresh or brackish water and return once to oceanic spawning grounds to breed and die (Tesch 1977). The family has been traced back to the Middle Eocene, some 45 million years ago (Cavender 1986).

Although the true eels, order Anguilliformes, are represented in North American fresh waters by only one species, the group is large and diverse; 21 families and 720 species are recognized by Castle (1984). Almost all species are marine and many inhabit the deep sea. Anguilliforms have an evolutionarily advanced, serpentine body form, but in fact they are rather primitive among bony fishes. Their nearest relatives include bonefishes, tarpons, and ladyfishes—herringlike fishes with body forms typical of most fishes. Phylogenetic linkage of true eels to bonefishes and allies is based largely on the leptocephalus type of larva common to them (Greenwood et al. 1966; Castle 1984; Smith 1984). Characteristics of this larva include a highly flattened, often ribbonlike body and major reduction in size during metamorphosis.

The extremely elongate body plan of eels is highly successful. The body form is termed anguilliform, and the typical mode of traveling—by synchronous undulations of the body—is named anguilliform locomotion. Although allowing open-water swimming, this body and locomotion type is specialized for entering crevices and burrowing in soft sediments, thus permitting eel-like forms to both hunt and hide in places not normally entered by most fishes, and to back out of them by reversing the direction of the undulations. Eel-like forms typically have the paired appendages reduced in size and capability, or one or both sets of the appendages are lost. The wide success of this morphotype is evidenced by its independent evolution in other fish lineages (e.g., lampreys, hagfishes, gymnotid eels, cusk eels, and blennies), certain salamanders (e.g., sirens), glass lizards, and snakes.

Name.—Anguill-, from *Anguilla*, a Latin word for eel.

Eels Genus *Anguilla* Shaw

A genus of about 15 eel species (Castle 1984).

Name.—See above.

American eel *Anguilla rostrata* (Lesueur)

SYSTEMATICS

Anguilla rostrata was described from New York in 1817 but its taxonomic status has been controversial for several recent decades. The American eel problem is actually a North Atlantic basin one, as the western Atlantic form at times has been considered conspecific with its eastern Atlantic counterpart, the Euro-

Lee et al 1980

James L. Oliver

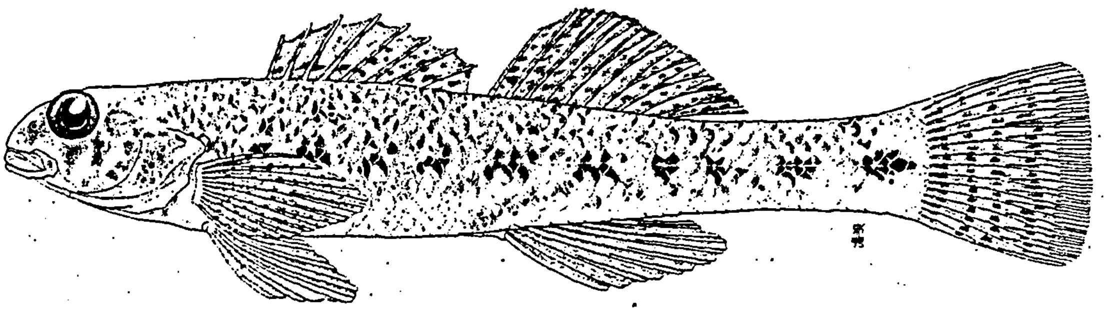
ATLAS OF NORTH AMERICAN FRESHWATER FISHES

V-537

1980 - et seq.

David S. Lee
Carter R. Gilbert
Charles H. Hocutt
Robert E. Jenkins
Don E. McAllister
Jay R. Stauffer, Jr.

with special thanks to:
George Burgess
James A. McCann
Steven P. Platania



We had originally intended that this volume be a collection of loose leaf pages. However since the additional cost was not large, and we were able to retain loose leaf format for those interested in adding and replacing pages, we decided to have it bound. This necessitated a short delay in production.

Library of Congress Cataloging in Publication Data

Lee, David Stephen, 1943-
Atlas of North American freshwater fishes.

Bibliography: p.
1. Fishes, Fresh-water--North America--Geographic distribution. 2. Fishes--Geographic distribution. 3. Fishes--North America--Geographic distribution.
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Publication #1980-12 of the North Carolina Biological Survey

North Carolina State Museum, John B. Funderburg, Director
North Carolina Department of Agriculture, James A. Graham, Commissioner of Agriculture.

James L. Oliver

V-538

Manooch 1984

FISHERMAN'S GUIDE

FISHES OF THE SOUTHEASTERN UNITED STATES

BY CHARLES S. MANOOCH, III

ILLUSTRATED BY DUANE RAVER, JR.

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FISHES OF THE SOUTHEASTERN UNITED STATES

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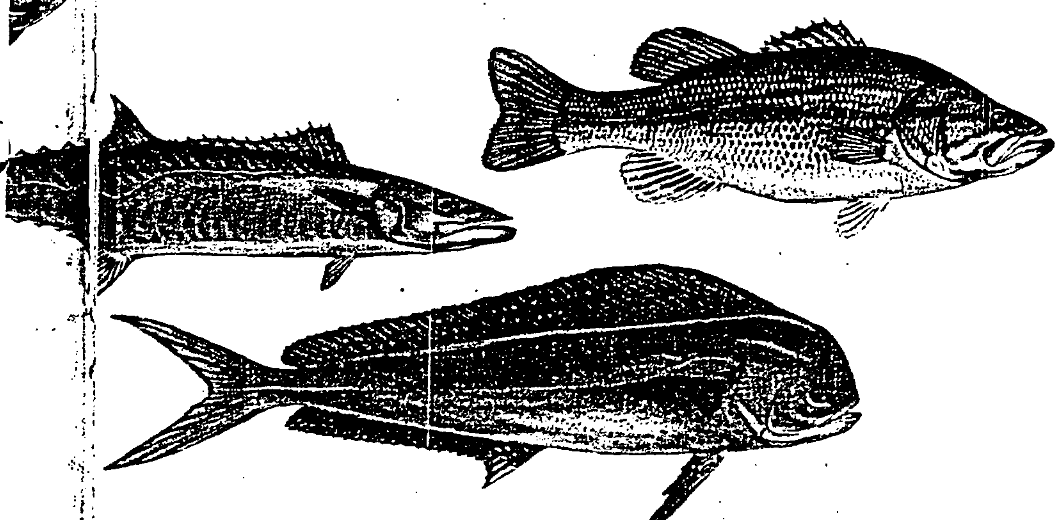

NORTH CAROLINA STATE MUSEUM OF NATURAL HISTORY
RALEIGH, NORTH CAROLINA 1984

May-June 2005

BARTON C. MARCY JR. | DEAN E. FLETCHER | E. DOUGLAS MARTIN
MICHAEL H. PALLER | MARCEL J. M. REICHERT | PHOTOGRAPHS BY DAVID E. SCOTT

V-539

FISHES *of the* *Middle Savannah River Basin*

WITH EMPHASIS ON THE SAVANNAH RIVER SITE

Fishes of the Middle Savannah River Basin

With Emphasis on the Savannah River Site

BARTON C. MARCY JR.
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PHOTOGRAPHS BY
DAVID E. SCOTT

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American Eel
Anguilla rostrata
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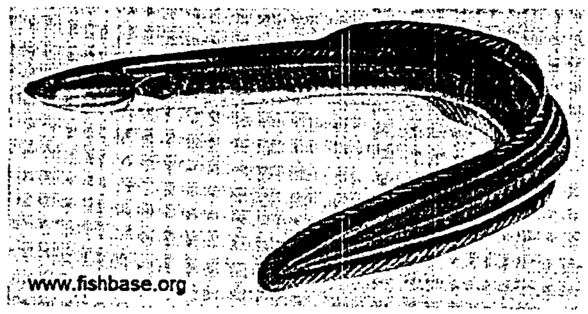

DESCRIPTION:

Taxonomy and Basic Description

The American eel, *Anguilla rostrata* (Lesueur 1817), belongs to the freshwater eel family, Anguillidae. Related species occur throughout the world, but the American eel is the only North American anguillid eel. Eels are snake-shaped and covered with a mucous layer that renders them slimy to the touch despite the presence of minute scales. A continuous, low fin runs from the middle of the back, around the tail, and ends behind the vent. Relatively small pectoral fins originate near the animals midline and immediately posterior to the head and gill-covers. Coloration varies with stage of maturity and habitat, but eels are generally dark olive, yellowish or slate-gray above and light below. Eels from dark, tannic acid streams are darker while those from clear streams and estuaries are lighter (pers. obs.).

The American eel is catadromous; it spawns in oceanic waters but uses freshwater, brackish and estuarine systems for most of its developmental life. Sexually mature adults, called silver eels, migrate from freshwater to the sea in fall. Their destination for spawning is the Sargasso Sea, an expansive portion of the central North Atlantic Ocean, east of the Bahamas and south of Bermuda. Adults are thought to die after spawning. The largest females produce nearly 20 million eggs (Barbin and McCleave 1997). Mature females in the southern portion of the eel's range are generally smaller and carry as few as 400,000 eggs (Wenner and Musick 1974). Eggs hatch into a brief pre-larval stage before transformation into the active leptocephalus stage. Leptocephali primarily drift with ocean currents for about a year before metamorphosing into the glass eel stage (Sheldon 1974). Glass eels are shaped like adults, but are transparent and smaller, reaching lengths of 5 to 7 cm (2 to 3 inches) (Hardy 1978). Glass eels actively migrate across the continental shelf and move into estuaries and tidal river reaches in late winter and early spring, apparently by detecting temperature gradients and the scents associated with freshwater (Facey and Van Den Avyle 1987). Glass eels feed little or not at all, but within weeks of entering estuaries and tidal rivers the small eels begin to feed and become pigmented, at which time they are called elvers and resemble miniature adults in coloration and other physical features. While some elvers move far into inland habitats, others remain in brackish and estuarine areas. Both glass eels and elvers migrate primarily at night and are able to move beyond obstacles that prevent passage of most aquatic species. Small eels can climb vertical walls, including low dams, as long as surfaces are damp and textured. The final inland resident stage is called the yellow eel and includes all eels greater than 10 cm (4 inches). Yellow eels may gradually move upstream over many years, with most movement occurring during spring and fall when water temperatures are moderate. However, larger yellow eels may settle in specific areas and have been found to occupy distinct home ranges (Gunning and Shoop 1962). Adult females are larger than males and may grow to lengths of nearly 1.0 m (40 inches), but most adults are 0.6 m (24 inches) or less. Maturation occurs from 3 to 24 years of age (ASMFC

2000), with males generally maturing at a younger age and smaller size than females. Eels as old as age 15 have been recorded in South Carolina (Harrell and Loyacano 1980).

American eels are opportunistic carnivores, feeding on a vast array of animal life depending on the size of the eel and the availability of prey within a given habitat. Larger eels feed primarily on small fishes and benthic invertebrates, including crustaceans, aquatic insects, worms and mollusks. Elvers and small yellow eels feed primarily on aquatic insects, small crustaceans and worms. Elvers collected from Cooper River consumed mostly midge larvae, cladocerans (zooplankton), amphipods (small crustaceans) and fish parts (McCord 1977). Adults taken from the same study area fed primarily on fish parts, elvers (eels can be highly cannibalistic) and terrestrial isopods (McCord 1977). In estuaries, eels often feed on blue crab (*Callinectes sapidus*) and polychaete worms (Wenner and Musick 1975). Both blue crab and horseshoe crab (*Limulus polyphemus*) are used as bait in trap fisheries for American eel in Chesapeake Bay and elsewhere.

Elvers are not only preyed upon by larger eels but are also eaten by many fishes, both game and non-game species. Small yellow eels up to 46 cm (18 inches) in length are used as bait for striped bass and cobia. Eels are also consumed by other predatory fishes such as largemouth bass (*Micropterus salmoides*) and bowfin (*Amia calva*) (pers. obs.) and are likely preyed upon by opportunistic predatory fish like non-native flathead catfish (*Pylodictis olivaris*). American eels are also included in the diets of fish-eating birds and mammals, such as mink (*Mustela vison*) (Sinha and Jones 1967, Seymour 1974). American eels are a valuable part of the many ecosystems they inhabit during various growth stages. Dams and other impediments to migration have eliminated the American eel from many historical habitats in South Carolina (USFWS 2001). The effects of the loss of American eels from aquatic food webs, though not quantified, may be substantial (Freeman et al. 2003).

Status

The American eel currently has no special status under state or federal regulations; however, a petition was filed in late 2004 with the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) to have the American eel listed as an endangered species. The Atlantic States Marine Fisheries Commission (ASMFC) has published a management plan for the conservation of this species in response to perceived declines (ASMFC 2000).

POPULATION DISTRIBUTION AND SIZE

One genetically similar population is thought to occur along the Atlantic coast (Williams and Koehn 1984). However, eels become resident as sub-populations in drainage basins throughout the range of the species until they become sexually mature. Accordingly, many sub-populations by drainage basin and region collectively comprise the North American population. The complex life cycle contributes to the difficulty in determining the population status of this species. Furthermore, the American eel has been poorly studied through much of its range. Historical data are scant for most areas of the Atlantic coast; no such information exists for South Carolina. Long-term data sets collected the northeastern United States and southeastern Canada indicate declines in both recruitment of juveniles and in adult populations (ASMFC 2000). Directed fisheries for silver eels have shown precipitous declines in catch per unit of effort (ASMFC 2000). Long-term data for elvers at Conowingo Dam fish lift on the Susquehanna River, Maryland indicate a declining trend from 1974 through 1996 (ASMFC 2000). Eel migration data from 1984 to 1995 indicate significant negative trends for yellow and/or silver eels in Ontario, Quebec, New York and Virginia (Richkus and Whalen 2000). Since there is likely a single genetic stock throughout the range, sub-population declines in any region or drainage basin can impact the entire population. The largest declines have been indicated over the past two decades. Dramatic declines in the northern portion of the American eel's range are important since sub-populations in this region carry the highest reproductive potential (Casselman 2003).

The American eel occurs along the Atlantic coast from Canada to Central and South America. Within South Carolina, eels occur from estuaries to the headwaters of coastal streams and at least as far inland as the fall line in longer river basins, including the Savannah, Santee and Pee Dee. Although the American eel is capable of traversing obstacles that may completely restrict dispersal of other fishes, both eel distribution and population size may be limited by dams and other impediments to migration. Historical records show that American eels occur in the Santee basin well inland of the fall line and into North Carolina (USFWS 2001). Similar historical distributions occurred for the Waccamaw–Pee Dee Basin and are likely to be present in the Savannah River basin.

American eel populations within the Santee-Cooper River watershed inland of Pinopolis, St. Stephen and Wilson Dams are likely well below numbers present prior to impoundment of the Santee-Cooper lakes in the 1940s. Observations from St. Stephen Dam indicate rather poor passage success for the American eel (D. Cooke, SCDNR, pers. comm., 2004). Fish passage at Pinopolis Dam on Cooper River is provided by navigational lock. Such passage systems are not considered to be particularly effective for American eels because of great fluctuations in water flow that occur during lock operations (Lary and Busch 1997). Dams on the Savannah and Waccamaw-Pee Dee drainages are well inland and probably do not significantly restrict eel distribution.

HABITAT/NATURAL COMMUNITY REQUIREMENTS

The American eel is widely distributed in many aquatic habitats including estuarine, brackish and freshwater tidal channels; tidal creeks; coastal impoundments; ponds; lakes and nearly all accessible freshwater habitats associated within river basins as far inland as the fall-line and beyond. Males are generally restricted to estuarine and brackish habitats while females are found more often in freshwaters. Among freshwater habitats, eels seem to be most abundant in streams, but occupy all habitats having sufficient food resources and well-oxygenated water. A high density of yellow eels has been observed in the upper South Edisto River, where single channels branch into a braided or intertwined network of small creeks within swamp forest. Yellow eels are also present in high densities in the middle Savannah River in relatively shallow, non-navigable reaches characterized by riffles and pools with rocks and submerged aquatic vegetation (pers. obs.). American eels are dependent upon access to such diverse habitats for growth and maturation, as well as free downstream passage for spawning migration. Sexually mature adults are dependent upon the vast expanses of the North Atlantic Ocean and the Sargasso Sea.

THREATS

Because of its complicated life cycle, the American eel population faces a broad range of threats, some of which are specific to a particular growth stage. Since males and females largely utilize separate habitats, impacts in a given region may affect the sex ratio of the eel population. Dams and causeways obstruct access to a diversity of habitats, which may limit basin-specific and statewide populations. The Pee Dee, Edisto, and Santee coastal drainages have suffered an 83 percent reduction in unobstructed stream habitat (Busch et al 1998). Impingement (entrapment) and entrainment (carried through) in water intakes and turbines are sources of mortality on seaward-migrating eels.

The American eel is sensitive to low dissolved oxygen levels (Hill 1969, Sheldon 1974) in water typically found below dams. Logging in swamp forests may also cause lowered dissolved oxygen by increasing siltation and water temperature. Contaminants such as heavy metals, dioxin, chlordane and polychlorinated biphenyls (PCBs) can bioaccumulate and cause acute toxicity or reduced productivity (Hodson et al. 1994).

Dredging can result in many impacts to American eels. Physical injury or mortality may result from entrainment of seaward-migrating adults. Increased turbidity or suspended sediments may negatively affect migration of adults, glass eels and elvers. Dredging may also cause changes in salinity regimens that could impact eel distribution and prey availability.

Spawning habitat may be adversely affected due to seaweed (*Sargassum* sp.) harvest in the Sargasso Sea. Spawning habitat and success is also likely to be affected by pollution like oil spills.

Dewatering freshwater streams for irrigation and other water removal projects decreases habitat availability for American eels and exacerbates any existing areas of poor water quality. Nonpoint source runoff from residential areas, roads and golf courses can have a negative impact on floodplain ecosystems and impact water quality. Potential overfishing or excessive harvest of juveniles (glass eels and elvers) could negatively impact localized populations. Competition and predation from non-native species, particularly flathead catfish (*Pylodictis olivaris*) and blue catfish (*Ictalurus furcatus*) is also a threat to American eels. Both of these catfish are piscivorous and opportunistic; they will feed on any fish that can fit in their mouths. Because both of these species are found in habitats frequented by elvers (pers. obs.), predation on eels by these catfish is a concern. Additionally, non-indigenous pathogens or parasites such as the Asian swimbladder nematode (*Anguillicola crassus*), has been shown to have significant negative impacts on the European eel (*Anguilla anguilla*) and on captive American eels in South Carolina and Texas (ASMFC 2000).

Changes in oceanographic conditions may alter oceanic currents, thereby potentially altering larval transport and recruitment of juveniles across the continental shelf. The cause of these changes is unknown, but global warming may play a part (ASMFC 2000).

CONSERVATION ACCOMPLISHMENTS

An interstate fisheries management plan (IFMP) has been developed for the American eel under the auspices of the ASMFC. The original IFMP for the American eel was completed in 2000 and is currently in the process of being amended. The plan established a framework of recommendations for protecting or enhancing eel sub-populations by state and region.

The IFMP required the states to control and limit directed effort in both bait and commercial eel fisheries in South Carolina. Beginning in 2001, states were required to collect and monitor catch and effort statistics for American eel commercial fisheries and to limit effort at levels achieved in 2000. As a result, SCDNR capped participation at 10 license holders and capped gear use as well. The permitting system that emerged from the IFMP mandate has greatly enhanced SCDNR's ability to initiate proactive controls over American eel fisheries. In addition, the plan required states to limit recreational harvest through the establishment of several regulations: the possession limit is not to exceed 50 eels; the minimum size limit is 15 cm (6 inches); and sale of American eels is prohibited without a license.

Many dams in South Carolina are currently, or are soon to be, undergoing Federal Energy Regulatory Commission (FERC) re-licensing, which includes considerations for improved access and migration of aquatic species. Therefore, increasing opportunities for passage are possible in the future.

CONSERVATION RECOMMENDATIONS

- Conduct statewide eel distribution and population surveys to make prioritized decisions for restoration and passage.
- Inventory sources of American eel mortality and formulate remedies where practical.
- Determine contaminant levels in eel tissues and relate those to mortality and reproductive success.
- Investigate impacts of logging in swamp forests on water quality and habitat.
- Determine impacts to American eel populations of dewatering freshwater streams.
- Expand the American eel young of the year survey to additional sites throughout the State's immediate coastal region.
- Determine size, sex, and age structures for each sub-population of American eels.
- Determine potential presence and distribution of the Asian swimbladder nematode (*Anguillicola crassus*).
- Determine potential impacts to American eels from competition and predation by non-native species.
- Determine the scope and impact of American eel harvest on sub-populations.
- Conduct genetics studies to document sub-populations by region or river basin.
- Investigate opportunities to provide passage at dams and other obstructions that are not under FERC authority.
- Develop more cost-effective and efficient techniques for providing both upstream and downstream passage of American eels at migration barriers.

- Where possible, improve access to a full diversity of habitats by removing, breeching or bypassing impediments to migration such as nonfunctional dams, dikes or causeways.
- Partner with NMFS, USFWS, United States Army Corps of Engineers and non-governmental organizations (NGOs) to promote the inclusion of fish passage designs, wherever prescribed, that can successfully provide two-way passage of American eel.
- Build partnerships with NGOs, permitting authorities and county and local governments to improve and implement the use of Best Management Practices (BMPs) in agriculture and urban development activities to reduce siltation and contaminant input.
- Partner with the Department of Health and Environmental Control to develop or improve water removal guidelines for agricultural, civil or industrial purposes that protect American eels.
- Work with municipalities and landowners to direct forestry activities away from floodplain areas.
- Work with the United States Army Corps of Engineers to identify dredging protocols that consider the timing of eel migration.
- Revise South Carolina eel regulations to limit harvest of any eel life stage or sub-population.
- To the extent possible, control and prevent further distribution of non-native blue and flathead catfish populations.
- Form an alliance with other state and federal agencies as well as NGOs to implement range wide conservation and management of American eel as described in the ASMFC IFMP.
- Partner with the South Atlantic Fishery Management Council (SAFMC) to promote implementation of the Fishery Management Plan for Pelagic Sargassum Habitat of the South Atlantic Region.
- Promote changes in water release protocols for dams that will restore or approximate natural flow regimens and increase minimum flows.
- Institute permitting protocols for aquaculture and pet fish industries that require certification of the absence of diseases and parasites for all *Anguilla* species.
- Participate in interstate research examining the effects of oceanic changes on distribution of larval American eel and how these changes may be related to global warming.
- Develop education and outreach programs that distribute information to governments, civic groups, educational systems and NGOs about critical habitat needs, threats and potential conservation actions for the American eel.

MEASUREMENTS OF SUCCESS

One measure of success would be to expand SCDNR's American eel monitoring program to more areas over a more appropriate time period (as outlined in ASMFC plans) to document distribution and population trends. Another measure of success would be to document stable to increasing American eel population trends in response to improved conditions in aquatic ecosystems and improved access to suitable habitats, as outlined in the 'recommendations' section.

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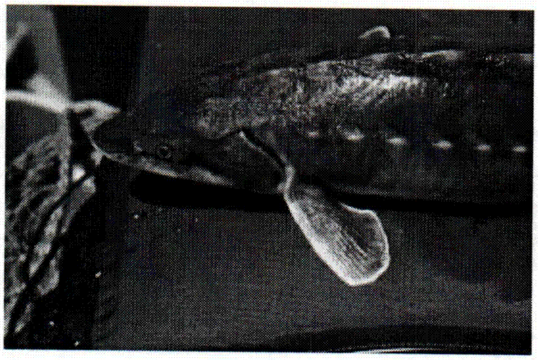
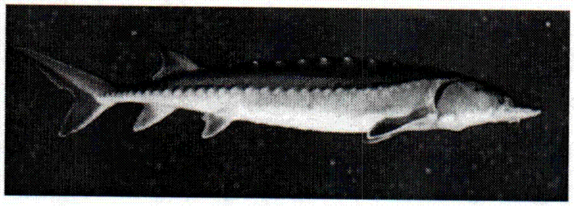
(NMFS 2004)

NMFS 2004

Common Name: **Atlantic Sturgeon**





Scientific Name: *Acipenser oxyrhynchus oxyrhynchus*
Area of Concern: Western Atlantic - Labrador, Canada through the St. Johns River, Florida
Year First Listed as a "Species of Concern": 1988 and formally retained in 1998

V-477

Species Description:

The Atlantic sturgeon is a subtropical, anadromous species. Spawning adults migrate upriver in spring, beginning in February-March in the south, April-May in the mid-Atlantic, and May-June in Canadian waters. In some areas, a small spawning migration may also occur in the fall. Spawning occurs in flowing water between the salt front and fall line of large rivers. Following spawning, males may remain in the river or lower estuary until the fall, females typically exit the rivers within four to six weeks. Adults forage on benthic invertebrates (mussels, worms, shrimp), live up to 60 years, reach lengths up to 14 feet, and weigh more than 800 pounds. Juveniles move downstream and inhabit brackish waters for a few months; at about 76-92cm TL, they move into coastal waters. Age of female sexual maturity is thought to be clinal: 7-19 years in SC, 15-30 in the Hudson River, and 27-28 years in the St. Lawrence River. Males mature at younger ages and smaller sizes that females also in clines: 5-13 years in SC, 11-20 years in the Hudson River, 22-34 years in the St. Lawrence River. Atlantic sturgeon are probably not annual spawners; males likely spawn more frequently than females. Tagging data indicate that immature Atlantic sturgeon travel widely once they emigrate from their natal rivers.

Rationale for "Species of Concern" Listing:

Demographic and Diversity Concerns:

Despite extensive mixing in coastal waters, statistically significant genetic differences between riverine stocks have been identified. However, not all portions of the species' range have been represented in the genetic testing.

Factors for Decline:

A large U.S. commercial fishery (100,000 - 250,000 lbs/yr) existed for the Atlantic sturgeon from the 1950's through the mid-1990's; the origin of the fishery is dated back to colonial times. The Atlantic sturgeon is managed under a Fishery Management Plan implemented by the Atlantic States Marine Fisheries Commission; a coast-wide moratorium on the harvest of wild Atlantic sturgeon was implemented in late 1997/early 1998. This moratorium is to remain in effect until there are at least 20 protected year classes in each spawning stock (anticipated to take up to 40 or more years). Most of the population data available before the moratorium were fishery-dependent, since the moratorium there have been few surveys to assess status and abundance. Cultured Atlantic sturgeon continue to be a valued commercial fish for both its flesh and their eggs (roe). Furthermore, because the sturgeon is dependant on the estuarine and freshwater habitat, habitat degradation continues to be a threat. Such factors included in habitat degradation are industrial and municipal pollution,blockage to access by dams, channelization or elimination of backwater habitats, de-watering of streams, and physical destruction of spawning grounds. Although currently there are no known disease organisms threatening the Atlantic sturgeon populations, there is concern that non-indigenous sturgeon pathogens could be introduced through aquaculture operations.

Status Reviews/Research Completed or Underway:

Apart from the National Marine Fisheries Service and the U.S. Fish and Wildlife Service, many of the programs set up for conservation of the Atlantic sturgeon are created by the Atlantic States Marine Fisheries Commission's Amendment 1 to the Atlantic sturgeon Fishery Management Plan, including measures for preservation of existing habitat, habitat restoration and improvement, monitoring of bycatch and stock recovery, and breeding/stocking protocols. Other organizations involved with Atlantic sturgeon conservation include, but are not limited to, State and local governments, private and conservation organizations which would include the Hudson River Foundation.

The Atlantic Sturgeon status review was completed in September 1998 in response to a petition, and it was scheduled to be updated in 2003 (See FR notice). The actual update should occur in 2004. In 1998 NMFS and FWS determined that Atlantic sturgeon did not warrant listing as threatened or endangered under the ESA. However, because of concerns regarding its status and uncertainties, NMFS retained this species on its candidate list. Now the Atlantic sturgeon is considered by NMFS to be a species of concern.

For further information on this Species of Concern, or on the Species of Concern Program in general, please contact Ms. Marta Nammack, NMFS, Office of Protected Resources, 1315 East West Highway, Silver Spring, MD 20910, (301)713-1401, Marta.Nammack@noaa.gov *; or Kimberly Damon-Randall, NMFS, Northeast Region, Protected Resources Division,* One Blackburn Drive, Gloucester, MA 01930-2295, (978) 281-9328, x6535, Kimberly.Damon-Randall@noaa.gov.

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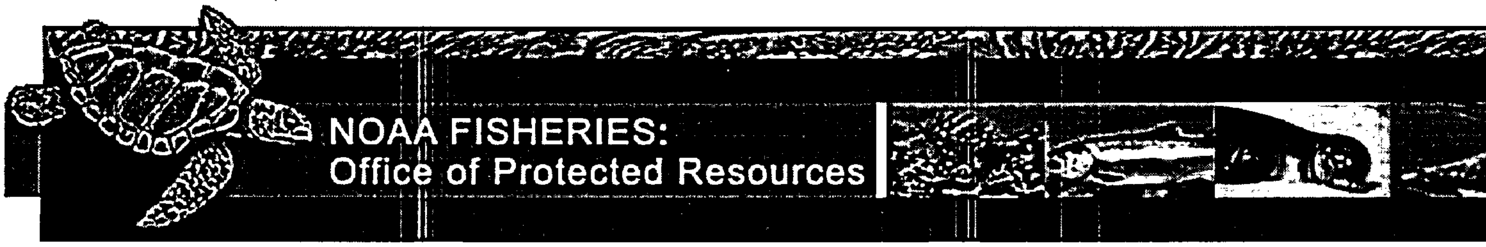

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Northern Right Whale
(Eubalaena glaclalis)
Photo: NOAA

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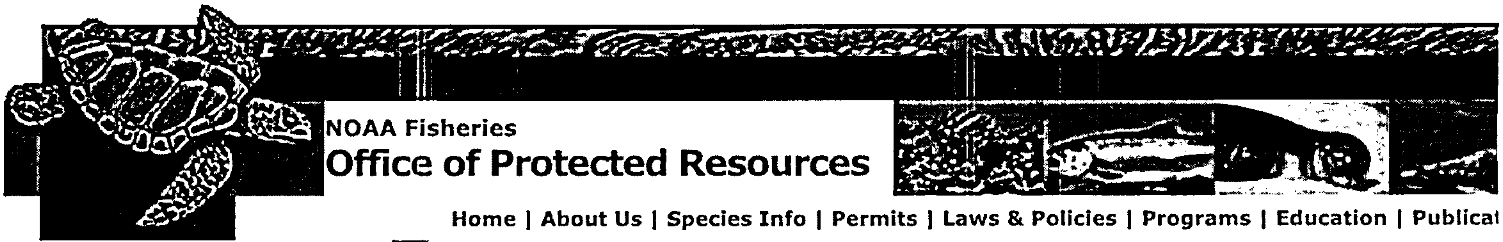

Species Information

The Office of Protected Resources works to conserve and recover species listed under the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA) in partnership with NOAA Fisheries Regions and Science Centers, environmental organizations, industry groups, other Federal and state agencies, and the academic community.

Species Numbers, Types, and Status
There are 1,300 U.S. "species" listed under the ESA. The Office of Protected Resources manages mostly marine and anadromous species, and the U.S. Fish and Wildlife Service manages the remainder of the listed species, mostly terrestrial and freshwater species.

The Office of Protected Resources manages:

- 64 ESA-listed species
- 40 ESA species of concern
- ~160 marine mammal stocks as reported in the MMPA stock assessment reports

Threats
Key threats to marine species are largely due to human impacts, including accidental capture in fishing gear, habitat destruction, pollution, overharvest, and ship strikes. These threats may contribute to a species' status as threatened or endangered.

For More Information
Critical Habitat
Integrated Taxonomic Information System
Marine Mammal Stock Assessment Reports
Recovery Planning
Status Reviews
U.S. Fish & Wildlife Service Endangered Species Program


Marine Mammals


Marine Turtles


Marine & Anadromous Fish

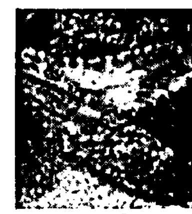
Marine Invertebrates & Plants

Photo Credit
Green turtle: Ursula Keuper-Bennett & Peter Bennett
Northern right whale: NOAA
Chum salmon: NOAA
White abalone: NOAA

For Kids & Teachers

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Responsible Wildlife Viewing
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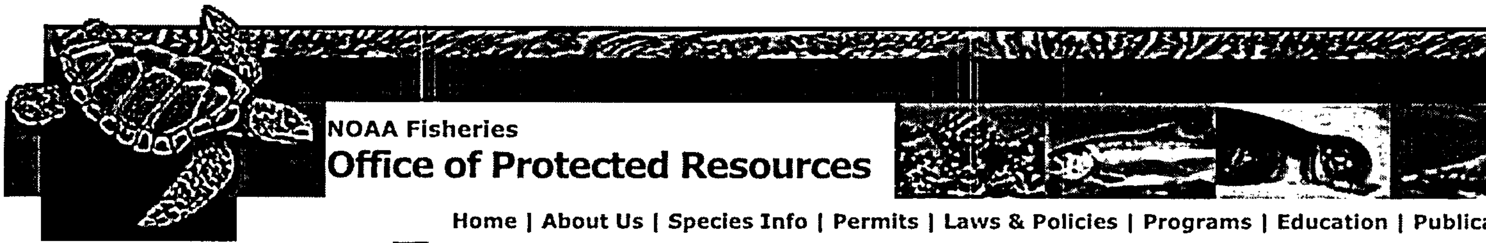
Report Wildlife Harassment
Call NOAA's Office of Law Enforcement 24-hour hotline: (800) 853-1964



Marine and Anadromous Fish

Overview
NOAA Fisheries has jurisdiction over most marine and anadromous fish listed under the Endangered Species Act (ESA). Marine fish spend their entire life in salt water. Anadromous fish are born in fresh water, migrate to the ocean to grow into adults, and then return to fresh water to spawn.

Status of Fish Species
The majority of fish listed as endangered or threatened under the ESA are Pacific salmonids, though the Gulf of Maine Atlantic salmon, U.S. population of smalltooth sawfish, shortnose sturgeon, and totoaba are also protected under the ESA. Other fish of interest are species of concern.

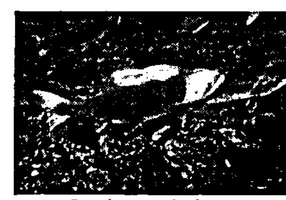
If different populations of a fish species have been listed under the ESA as "distinct population segment (DPS)" or "evolutionarily significant unit (ESU)", some DPSs or ESUs may be threatened and others endangered.

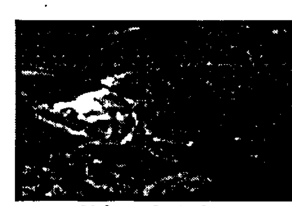
(E = "endangered"; T = "threatened"; C = "candidate species"; S = "species of concern"; F = "foreign")

Species	Status
bocaccio [pdf] *(Sebastes paucispinis)*	S
cowcod [pdf] *(Sebastes levis)*	S
croaker, striped [pdf] *(Bairdiella sanctaeluciae)*	S
cusk [pdf] *(Brosme brosme)*	S
grouper, nassau [pdf] *(Epinephelus striatus)*	S
grouper, warsaw [pdf] *(Epinephelus nigritus)*	S
hake, Pacific [pdf] *(Merluccius productus)*	S


Humphead Wrasse
(Cheilinus undulatus)
Photo: Brian Zgliczynski, NOAA

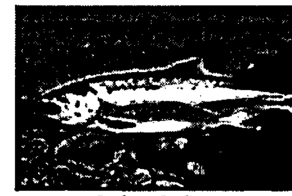

Nassau grouper
(Epinephelus striatus)
Photo: Stephania Bolden, NOAA


Sockeye Salmon
(Oncorhynchus nerka)
Photo: Travis Nelson, Washington Dept. of Fish & Wildlife

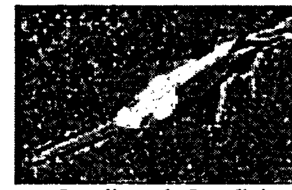

Chinook Salmon
(Oncorhynchus tshawytscha,
Photo: NOAA

halibut, Atlantic [pdf] *(Hippoglossus hippoglossus)*	S
hind, speckled [pdf] *(Epinephelus drummondhayi)*	S
marlin, white [pdf] *(Tetrapturus albidus)*	S
parrotfish, bumphead [pdf] *(Bolbometopon muricatum)*	S
pipefish, opossum [pdf] *(Microphis brachyurus lineatus)*	S
rivulus, mangrove [pdf] *(Rivulus marmoratus)*	S
salmon, Atlantic *(Salmo salar)*	E/S
salmon, chinook *(Oncorhynchus tshawytscha)*	E/T/S
salmon, chum *(Oncorhynchus keta)*	T
salmon, coho *(Oncorhynchus kisutch)*	E/T/S
salmon, sockeye *(Oncorhynchus nerka)*	E/T
sawfish, smalltooth *(Pristis pectinata)*	E/T
sawfish, largetooth [pdf] *(Pristis pristis)*	S
shad, Alabama [pdf] *(Alosa alabamae)*	S
shark, dusky [pdf] *(Carcharhinus obscurus)*	S
shark, night [pdf] *(Carcharinus signatus)*	S
shark, sand tiger [pdf] *(Carcharias taurus)*	S
silverside, key [pdf] *(Menidia conchorum)*	S
skate, barndoor [pdf] *(Dipturus laevis)*	S
skate, thorny [pdf] Raja radiata	S
smelt, rainbow [pdf] *(Osmerus mordax)*	S

Chum Salmon
(Oncorhynchus keta)
Photo: NOAA



Coho Salmon
(Oncorhynchus kisutch)
Photo: NOAA



Smalltooth Sawfish
(Pristis pectinata)
Photo: NOAA

Barndoor Skate
(Dipturus laevis)
Photo: NOAA

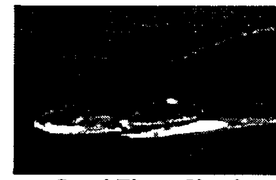
Bocaccio
(Sebastes paucispinis)
Photo: NOAA

Cowcod
(Sebastes levis)
Photo: NMFS Southwest Fisheries Science Center

Cusk

steelhead trout [pdf] *(Oncorhynchus mykiss)*	E/T
sturgeon, Atlantic [pdf] *(Acipenser oxyrinchus oxyrinchus)*	S
sturgeon, green [pdf] *(Acipenser medirostris)*	S
sturgeon, gulf (*Acipenser oxyrinchus desotoi*)	T
sturgeon, shortnose (*Acipenser brevirostrum*)	E
totoaba (*Totoaba macdonaldi*)	E (F)
topminnow, saltmarsh [pdf] *(Fundulus jenkinsi)*	S
wolffish, Atlantic [pdf] *(Anarhichas lupus)*	S
wrasse, humphead [pdf] *(Cheilinus undulatus)*	S

(Brosme brosme)
Photo: NMFS Northeast Region



Sand Tiger Shark
(Carcharias taurus)
Photo: NOAA's National Ocean Service

For information on other fish managed by NOAA Fisheries, such as commercial, recreational, and subsistence fisheries, visit the site of the Office of Sustainable Fisheries.

More Information
Critical Habitat for Pacific Salmon
Essential Fish Habitat
NOAA Fisheries Office of Sustainable Fisheries
Pacific salmon - NOAA Fisheries Northwest Region
Pacific Salmon Publications - NOAA Fisheries Northwest Region

(NMFS 2006)

section 2.4.2

NMFS Landings Query Results

You Asked For the Following:

- Year : From: 1970 To: 1975
- Species : SHAD, AMERICAN
- State : Georgia

V-474

Year	Species	Metric Tons	Pounds	$
1970	SHAD, AMERICAN	241.1	531,500	140,168
1971	SHAD, AMERICAN	190.5	420,000	133,185
1972	SHAD, AMERICAN	156.0	343,900	111,468
1973	SHAD, AMERICAN	108.6	239,400	90,838
1974	SHAD, AMERICAN	73.3	161,700	62,820
1975	SHAD, AMERICAN	82.6	182,000	99,273
GRAND TOTALS:	-	852.1	1,878,500	637,752

Cited as "NMFS 2006"

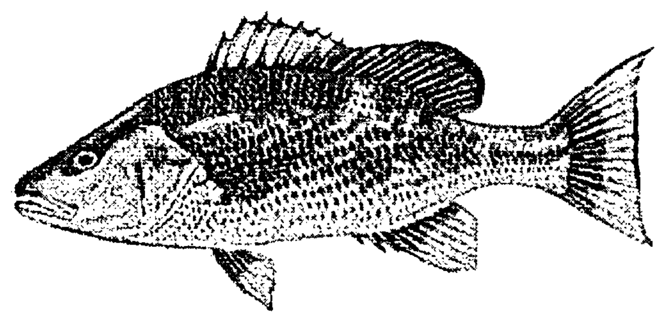
Commercial Fisheries

Annual Commercial Landing Statistics

To summarize landings for an individual species use (click on) the

Species Locator

to look up and enter the name in the SPECIES field. We recommend you look-up and use the NMFS common names because the query depends on matching the name in the SPECIES field with the species name in a master coding table. If there isn't an exact match the executed query will say that there were "no matching records." To summarize landings of all species, enter the phrase ALL SPECIES COMBINED or ALL SPECIES INDIVIDUALLY in the SPECIES field; the first option gives you total combined landings while the second option indicates total landings for each individual species.



Gray Snapper (*Lutjanus griseus*)
Photo Credit: Manooch and Raver, ©Copyright

SPECIES: SHAD, AMERICAN

YEAR RANGE:

Choose the year(s) to begin and end your data summary. If you want data for a single year, enter that year (e.g., 1992) in both the FROM and TO boxes. A word of caution, landings for the most recent year indicated are preliminary and sometimes are highly incomplete.

FROM: 1970 (Earliest Year)

TO: 1975 (Latest Year)

GEOGRAPHICAL AREA

STATE/AREA:

Georgia

Areas are arranged in geographical order by subregion. For example, the option "New England By State" will give you the landings for each of the five states listed after the option (Maine to Connecticut). The "New England" option will give you the total combined landings of the five states. The NMFS "Chesapeake" Region includes bay and oceanic landings for Maryland and Virginia. Florida is divided into three areas (east coast, west coast, and inland waters) in our surveys. Florida east coast and inland water landings are summarized with South Atlantic states and Florida west coast landings are summarized when Gulf landings are requested. The only way to get total Florida landings (west+east+inland waters) is to select the "Florida, State Total" option. Commercial landings for Washington, Oregon, California, Hawaii and Alaska are listed under the Pacific region.

OUTPUT FORM:

TABLE

The summarized data can be viewed in a table format by choosing the "Table" option from the OUTPUT FORM; this tabular data with subtotals can be printed by choosing the FILE PRINT option from the top menu bar. Choose the "ASCII File" option if you want to create a file of these data without the subtotals; the data file will not be output to your monitor.

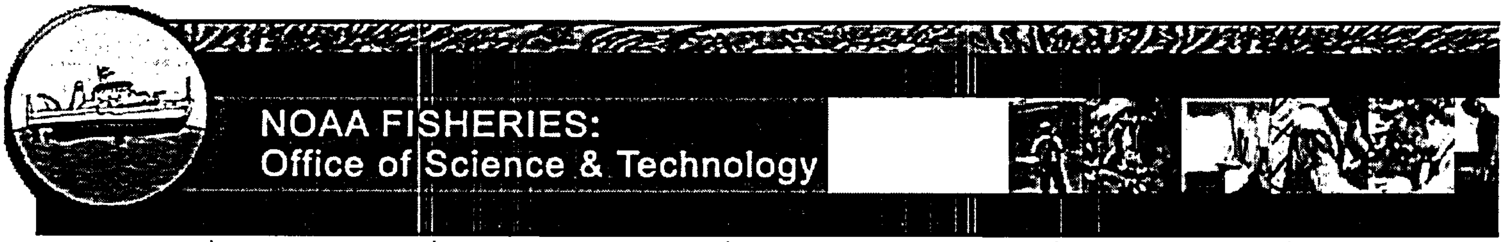
Submit Query Clear Entries

Return to Commercial Landings Home Page

E-mail us questions on commercial annual landings.

Photo Credits

All fish pictures, unless otherwise noted, are used with the permission of Charles S. Manooch, III and Duane Raver, Jr. These copyrighted pictures are from their book, "Fishermen's Guide: Fishes of the Southeastern United States.



Commercial Fishery Landings

- **Monthly Landings**
- **Annual Landings**
- **Landings by Gear**
- **Annual Landings with Group subtotals**
- **Landings Background**
- **Data/format changes** (April 2002)
- **Data Caveats**

Other Specialized Programs

- **Preliminary Annual Landings by Distance from Shore**
- **Great Lakes Landings**
- **Total Commercial Fishery Landings At An Individual U. S. Port For All Years After 1980**
- **Total Commercial Fishery Landings At Major U. S. Ports Summarized By Year and Ranked By Dollar Value**
- **Total Commercial Fishery Landings At Major U. S. Ports Summarized By Year and Ranked By Poundage**

Summary

The Fisheries Statistics Division of the National Marine Fisheries Service (NMFS) has automated data summary programs that anyone can use to rapidly and easily summarize U.S. commercial fisheries landings.

These programs allow you to query our commercial fishery data bases and summarize United States domestic commercial landings in several formats. Domestic fishery landings are those fish and shellfish that are landed and sold in the 50 states by U.S. fishermen and do not include landings made in U.S. territories or by foreign fishermen. You can summarize the pounds and dollar value of commercial landings by your choice of years, months, states and species for the years 1990 onwards. The volume and value of 1950 onwards landings can be summarized by: years, states and species; by years, states, species and fishing gears; or years, states, species, finfish or shellfish groups, and price per pound.

Data Caveats

Please read the caveats associated with these data before using them in any research, report or commercial endeavor. If you have questions about the data or are aware of any errors, write us at our **e-mail address** or call 301-713-2328.

We will make other fishery landings, vessel, fishing gear and other information available to users as time permits.

Reinert, et al. 2005

fisheries research

feature

Decline and Potential Recovery of Striped Bass in a Southeastern U.S. Estuary

Declines in striped bass (*Morone saxatilis*) populations have been well documented over the past 30 years. During the 1980s, Savannah River striped bass also suffered a population decline, when catch per unit effort (CPUE; #/hr) of large adults declined by 97% and egg production declined by 96%. Loss of freshwater spawning habitat through harbor modifications was identified as the primary cause. Population restoration began in 1990 and included stock enhancement and environmental remediation. Salinity levels in historic spawning and nursery habitats are now similar to those prior to the decline. Recently, egg production and CPUE of large striped bass both seem to be increasing. The increasing abundance of larger fish should result in continued increases in egg production, and eventually recruitment, and recent captures of wild-spawned larvae and juveniles confirm natural reproduction. However, current efforts to deepen the Savannah Harbor may preclude striped bass recovery by once again allowing saltwater intrusion into upper estuary spawning and nursery habitats. This case history may serve as another example of successful striped bass recovery efforts yet also underscores the need for continued monitoring and innovative research where populations are at risk or imperiled.

V-541

Thomas R. Reinert
Cecil A. Jennings
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Introduction

Over the last 30 years and for varied reasons, striped bass (*Morone saxatilis*) stocks across North America have suffered population declines, and in some cases, these stocks also have made notable recoveries. The best known of these was the Chesapeake Bay population decline of the 1970s. Although primarily blamed on overfishing, water quality effects were likely contributors to the decline as well (Goodyear et al. 1985; Price et al. 1985). Increasing eutrophication in upper bay areas reduced submerged aquatic vegetation cover and decreased oxygen levels, particularly during the warm summer months (Coutant 1985; Coutant and Benson 1990). However, this population has since recovered primarily through aggressive year-class protection, with stock enhancement and improvements in water quality probably playing minor roles (Richards and Rago 1999). Stock reduction in the Delaware River was attributed to excessive pollution (Chittenden Jr. 1971); however, the stock was declared recovered in 1998 (ASMFC 1998), presumably through habitat improvement and the overfishing protections afforded by the Chesapeake Bay recovery initiatives. The introduced population of striped bass in the Sacramento-San Joaquin delta declined in the 1970s and 1980s as well. Initial hypotheses for the decline included increased agricultural water withdrawals reducing freshwater flow and increased agricultural pesticide use, both negatively affecting early life history stages of striped bass (Stevens et al. 1985). Recent meta-analyses suggest possible density-dependent compensation between early life history stages and recruitment to the adult population, with the mechanism of decreased adult abundance yet to be identified (Kimmerer et al. 2000, 2001). Recovery efforts were initiated in the 1980s and continue to date. Roanoke River striped bass declined during the 1980s, primarily because of intense fishing pressure and reproductive failures caused by inadequate instream flows (Rulifson and Manooch 1990; Zincone and Rulifson 1991). Implementing prescribed minimum flows and strict management practices led to population recovery by 1997 (ASMFC 1998). Striped bass stocks south of the Roanoke River and along the Gulf Coast tend to be riverine and typically are smaller, supporting recreational but rarely commercial fisheries (Rulifson et al. 1982b). As such, few published reports exist on population trends for these stocks.

In Georgia, Atlantic Coast striped bass are native to the Savannah, Ogeechee, and Altamaha rivers (Hill et al. 1989) and have been introduced into other river systems and reservoirs throughout the state. Although commonly found in estuarine waters, striped bass in Georgia tend to be riverine, rarely entering the open ocean. However, movement between the Savannah and Ogeechee rivers via coastal waters occasionally has occurred (Dudley et al. 1977). As is common throughout their range, striped bass and striped bass hybrids (crossed with white bass, *M. chrysops*) provide highly popular fisheries in Georgia's rivers and reservoirs. In 2001, *Morone* fisheries accounted for a significant portion of the $0.5 billion in annual

(RRCC 1998)

http://www.robustredhorse.com/f/1998 Annual Mtg of RRCC.pdf

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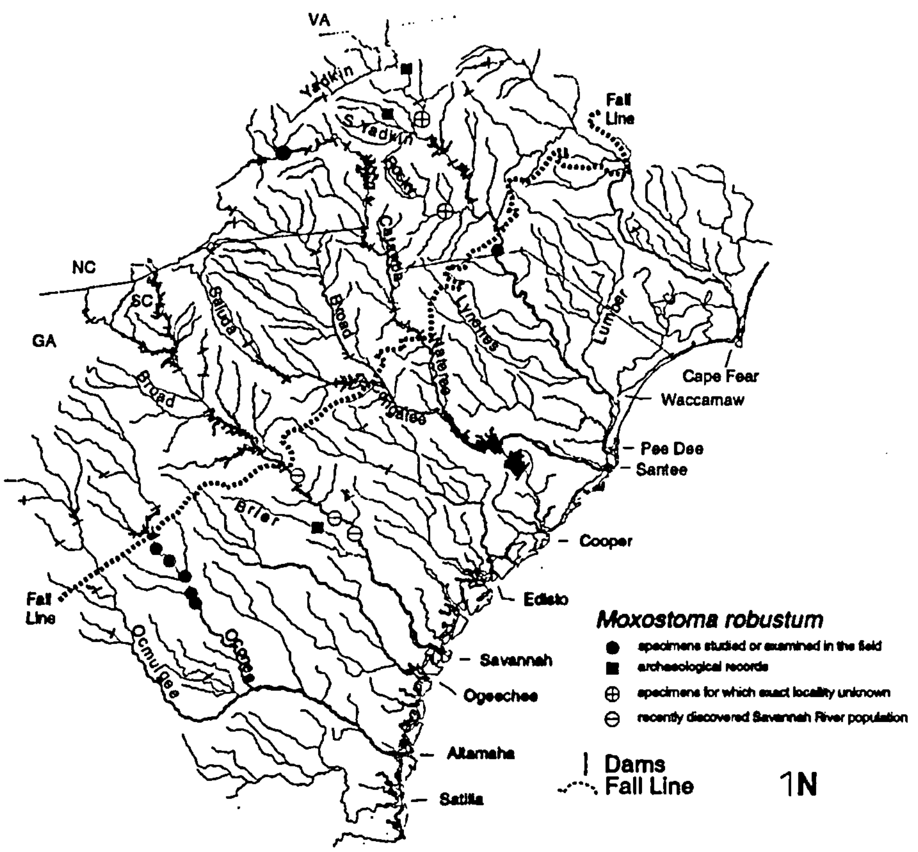
REPORT OF THE

ROBUST REDHORSE CONSERVATION COMMITTEE ANNUAL MEETING

SOCIAL CIRCLE, GEORGIA
OCTOBER 28 - 29, 1998



(The presumed range of the robust redhorse (Moxostoma robustum) on the South Atlantic Slope)

Meeting facilitated and report written by T. DeMeo
under contract with the United States Fish and Wildlife Service

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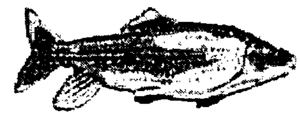
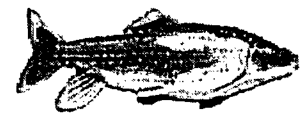
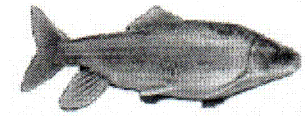




APPENDICES



Evidence of unsuccessful recruitment in the wild to 2 - 3 inches supports the conclusion that the Oconee population is in trouble. More definitive results can be gained through a refinement of the sampling techniques to find juveniles. There does seem to be a low level of recruitment evidenced by the 1998 collection. The absence of juveniles may be a sampling bias. A rigorous mark and recapture experiment to determine the population size, individual survivorship, and recruitment is required. The researcher believes that a long-lived species with a high level of survivorship will have a low level of recruitment. A determination of the level of recruitment that is needed to maintain the population must be made.

Results of Savannah River Sampling Conducted in 1998 — Scott Hendricks

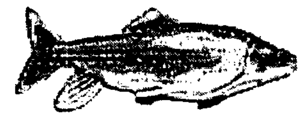
During routine sampling in October 1997, an adult robust redhorse was collected in the Savannah River near Plant Vogel. Portions of the Savannah River were surveyed for robust redhorse in 1998. The Georgia Power Company coordinated flows from Clarks Hill Lake with the U.S. Army Corps of Engineers to conduct additional sampling downstream of the 1997 find, between Augusta to Highway 301.

On May 20 and 21, 1998, seven (7) electrofishing boats participated in sampling the Savannah River between the New Savannah Bluff Lock and Dam to Highway 301. Sampling crews included: Georgia Department of Natural Resources, Wildlife Resources Division (WRD); UGA, Institute of Ecology; Coop Fish and Wildlife Research Unit; Georgia Power Company; U.S. Army Corps of Engineers; Tulane University; Kleinschmidt Associates; and Roanoke College, Virginia. Efforts were concentrated in meander bends with snags, areas having similar habitat as the Oconee. Even with the coordinated flows, the river was still high as a result of the spring rain events. After 15 hours of pedal time over two (2) days, no robust redhorse were found.

On June 3 and 4, 1998, sampling was conducted in the Augusta shoals area, about one (1) mile upstream of Interstate 20 downstream to about the 5th Street Marina. Again flows were coordinated with the U.S. Army Corps of Engineers. Sampling crews included: WRD; South Carolina Department of Natural Resources; UGA, Institute of Ecology; EDAW, Inc.; City of Augusta/Richmond County, Georgia; Georgia Power Company; Duke Power Company; Roanoke College, Virginia; and North Carolina State University, Museum of Natural History.

The sampling efforts concentrated on shallow, swift, rocky shoals, and shallow pools between rock ledge habitats. Five (5) electrofishing boats accumulating over 12.3 hours of pedal time captured four (4) adult robust redhorse, two (2) each day, and several more were observed. All four (4) fish were females, measuring between 620 - 675 millimeters in total length with a mean of 645 millimeters (25.4 inches). They weighed between 3.66 - 5.11 kilograms with a mean of 4.13 kilograms (9.1 pounds). Fin and egg tissue was collected and the females were given pit and floy tags. These fish did not exhibit severe scale loss and abrasions, presumably from spawning activity, as do fish from the Oconee River. They were transported to McDuffie (see Greg Looney's report, Results of 1998 Spawning Season) and then returned in good condition to the Savannah River near the capture site on June 8, 1998.

On October 15, 1998, one (1) robust redhorse was collected in deep water from a straight stretch of the Savannah River 11 miles downstream of Highway 301. This find, measuring 575 millimeters (22.6 inches) and weighing 2.9 kilograms (6.4 pounds), was 42 river miles downstream of the 1997 capture and 98 river miles downstream of the Augusta shoals catch.



The status of a Savannah River population remains entirely unknown. The Savannah, a large deep river, is difficult to sample making an estimate of the population hard and its potential as a reliable broodfish source unlikely. Furthermore, the Savannah River is one of the most heavily sampled rivers in the Southeast United States and until recently there were only two (2) known records. Efforts to estimate a population must target just robust redhorse; they will rarely be found while looking for other species.

The investigator recommends sampling the Ogeechee River for robust redhorse. While sampling for stocked fish in the Ogeechee, Tim Barrett who caught the Savannah River robust redhorse in October 1998, saw one (1) fish that could have been an adult robust redhorse. This sighting has not been verified but merits an intensive sampling focus.

Initial Results of Genetics Investigation of Hatchery-Reared Robust Redhorse Fingerlings; Genetic Characterization of the Savannah River Robust Redhorse Population — Ike Wirgin

Objectives of the genetics investigation of robust redhorse include: 1) to determine if there are multiple stocks of robust redhorse in the Oconee River; 2) to evaluate the genetic similarities in the Oconee and Savannah rivers; and 3) to compare the genetic diversity of the hatchery population to the adult Oconee River population. The focus of genetic research this year has been on the fin clip tissue collected from the four (4) robust redhorse captured in the Savannah River on June 3 - 4, 1998 and the one (1) captured in October 1997. Techniques typically used in genetic sequencing research involve: 1) allozyme proteins, which detect low levels of bi-parent genetic variability; 2) mitochondrial DNA, which detects moderate levels of maternal genetic variability; and 3) microsatellite DNA, which detects high levels of bi-parent genetic variability.

The five (5) Savannah River specimens were compared to Oconee River specimens using the microchondial DNA sequencing technique. Results showed genetic sequencing at 9 of 10 sites. Six (6) of the sites are polymorphic, which differ among individuals. Four (4) of those revealed fixed differences between the Oconee and Savannah river specimens indicating significant genetic divergence. The microsatellite analysis to compare the hatchery-reared to the Oconee River population is ongoing. Other results indicate no difference in the individual spawning aggregates in the Oconee River, but the testing has not been completed. The same analysis was conducted between the Savannah and the Oconee specimens; three (3) of the four (4) Savannah individuals demonstrated different alleles to the Oconee River specimens.

Preliminary conclusions argue that the Oconee River contains a single population of robust redhorse. The fixed differences between the Oconee and the Savannah specimens suggest that the two populations are genetically distinct. The researcher informed the RRCC to assume that the Oconee and Savannah rivers contain two different populations and cautioned against the mix of hatchery-reared robust redhorse between the two rivers.

Progress on Development of a Conservation Agreement to Facilitate Reintroductions of Robust Redhorse in Georgia — Mike Nichols

A draft of a Conservation Agreement with an associated Conservation Strategy designed to facilitate a stocking of the Ocmulgee River has been developed. The approach is a tool that can be used in managing the recovery of the robust redhorse. The RRCC MOU is flexible and addresses needs throughout the historic range. The Conservation Agreement deals specifically with the Ocmulgee River. It is more

RRCC 2003

(RRCC 2003)

The Robust Redhorse Conservation Committee is a voluntary stakeholder partnership charged with the overall responsibility for directing the recovery of the robust redhorse (Moxostoma robustum). The robust redhorse is a large, long-lived member of the redhorse sucker family. Adults can reach 30 inches in length and weigh up to 17 pounds, although the average length in sample populations is 25 inches and the average weight is 9 pounds. The maximum known age is 27 years. The fish has a thick, robust body with rose-colored fins and a fleshy lower lip. A two-page factsheet provides a quick overview of the fish and its recovery.

"Home"

http://www.robustredhorse.com

V-480

The Mystery Fish

Master naturalist Edward Drinker Cope first described the robust redhorse in 1870 based on a single 6-pound specimen that had been collected from the Yadkin River in North Carolina. The specimen was apparently destroyed and by the late 1800's all mention of the robust redhorse had dropped from the scientific literature. In 1980 and 1985, unidentified specimens were collected from the Savannah River (the boundary between Georgia and South Carolina) and the Pee Dee River in North Carolina and South Carolina, respectively. However, they were not properly identified as robust redhorse because the name had been misapplied to a related species.

In August 1991, fishery biologists with the Georgia Department of Natural Resources, Wildlife Resource Division, collected five unrecognized fish from the Oconee River downstream of Sinclair Dam while conducting an environmental assessment during the early stages of a Federal Energy Regulatory Commission relicensing of the dam. The unknown fish were sent to renowned ichthyologists who unraveled the taxonomic mystery determining that the Oconee specimens and the previously collected unknown fish were the lost robust redhorse. Once the taxonomic mistake was discovered and the 1980, 1985, and 1991 specimens were correctly identified, the collection of robust redhorse from the Oconee River signified the rediscovery of a species that had been lost to science for 122 years.

Following the 1991 rediscovery, efforts were made to locate other remnant populations of robust redhorse within its historic range, the Atlantic Slope Rivers from the Pee Dee River system in North Carolina to the Altamaha River system in Georgia. Despite extensive field surveys in the Pee Dee, Yadkin, Rocky, and Little rivers, North Carolina; the Catawba River, South Carolina; the Ogeechee and Broad rivers, Georgia; and the Savannah River, Georgia/South Carolina, no conclusive evidence for the existence of other populations was found at that time.

Creative Conservation Partnership

The Endangered Species Act encourages creative partnerships between the public and private sectors and among governmental agencies to conserve imperiled species and their habitat. In fact, Section 4 (b)(1)(A) of the ESA requires consideration of existing conservation efforts when determining whether a species should be listed as threatened or endangered. Since efforts to recover the robust redhorse were initiated in the spring of 1992, this preexisting conservation initiative was embraced when the robust redhorse was under consideration for species listing.

As a result, the Robust Redhorse Conservation Committee (RRCC) was established in 1995 under a Memorandum of Understanding (MOU) between state and federal resource agencies, private industry, and the conservation community in lieu of listing under the ESA. Partners to the robust redhorse recovery include thirteen signatory members to the

MOU, two cooperating members under the MOU, and a variety of university research and resource management facilities as affiliate members. The MOU is consistent with federal agency findings that the development and implementation of conservation agreements, management plans and similar documents are effective for conserving declining species making listing unnecessary in some instances.

Threats to the Robust Redhorse

Wild populations of robust redhorse are now known to exist in the Ocmulgee and Oconee rivers (Georgia), the Savannah River (Georgia/South Carolina), and the Pee Dee River (North Carolina/South Carolina). In addition, small stocked populations have been established by introducing fish in the Ocmulgee, Ogeechee, and Broad rivers in Georgia. While much has been learned about the fish since its discovery, many questions about its habitat, life history, and threats to its survival remain. Habitat loss and disruption of spawning migrations resulting from dams and impoundments, predation by introduced nonnative species, and significant deterioration of water quality due to sedimentation and pollution are believed to have contributed to the decline of the species. As well, the limited range of known populations and low rates of recruitment to the adult population represent threats to the species' future.

The complex and diverse problems facing the robust redhorse require the RRCC's interdisciplinary approach that uses a broad spectrum of experience, expertise, and management authority to maintain and restore this imperiled species. The RRCC is actively committed to the recovery of the robust redhorse throughout its former range by identifying priority conservation needs for the robust redhorse and its habitat and coordinating implementation of research and management programs for addressing those needs.

Partnership Accomplishments

To date, the RRCC has met as a full committee annually in partial satisfaction of requirements for conservation of the species as designated in the MOU. The annual meeting represents the only scheduled time for all interests to assess progress and to establish management directions that guide recovery efforts in the upcoming year and beyond. The annual meeting is the occasion to explore the scientific and management implication of research results and new data, to debate philosophical viewpoints, and to gather the collective expertise of fisheries and environmental management professionals. This dialogue, documented in RRCC Annual Meeting Reports, includes the best available science on the robust redhorse, which forms the basis of the RRCC's recovery and policy decisions.

A Conservation Strategy for the Robust Redhorse that provides overall conservation guidance to assure the continued survival of the species was adopted by the RRCC in 1998 and updated in 2003. It establishes short- and long-term goals conservation goals, describes the status and distribution of the species, discusses problems facing the species, and presents conservation actions to be implemented to accomplish the short- and long-term goals. Based on the Conservation Strategy, the RRCC participated in a new and innovative United States Fish and Wildlife Service policy to develop a Candidate Conservation Agreement with Assurances (CCAA) for the Robust Redhorse in the Ocmulgee River, Georgia. The CCAA involves the commitment of specified research and management actions in exchange for assurances to non-federal participants that further regulatory actions will not be undertaken if the legal status of the species were to change.

After publication in the Federal Register, the CCAA was signed as a collaborative effort by the United States Fish and Wildlife, the Georgia Department of Natural Resources and the Georgia Power Company to restore the species to the Ocmulgee River.

The RRCC has developed sufficient information on the robust redhorse and activities have expanded to the point that unifying policies were needed to implement the short- and long-term goals established in the Conservation Strategy. In 2002, the RRCC adopted the Robust Redhorse Conservation Committee Policies that describe the current understanding of this unique species and the processes under which the partnership operates.

The RRCC established an executive committee to manage the ongoing activities that implement research and management decisions. Research projects and management activities are undertaken by subsets of the RRCC and have resulted in a variety of research reports, master's theses, journal articles, and conference proceedings. Technical working groups were created to focus on specific populations with the expectation of developing river basin management plans. The first set of plans is in development for the Oconee River, Georgia; Broad River, South Carolina; and Pee Dee River, North Carolina and South Carolina. Technical working groups also are formed to address range-wide issues such as habitat restoration. The Habitat TWG has developed the Habitat Restoration Management Plan. In addition to a variety of articles in the popular press and newspaper articles, the RRCC undertakes education to inform the public on the robust redhorse and its unique rediscovery, loss of habitat and biodiversity concerns associated with alterations to riverine systems, and the wonders of the natural world.

Paradigm for the Future

The native habitats of the robust redhorse are typical southeastern rivers, equal parts wilderness beauty and significantly altered riverine systems. The rivers have been intensively fished for hundreds of years. In addition, state and federal resource agencies have undertaken surveys of the river systems in Georgia and the Carolinas for some time. In fact, the Savannah River is one of the most highly surveyed rivers in the Southeast, intensively sampled since the 1950's under the Atomic Energy Commission due to the location of the Savannah River Nuclear Site. For these rivers to reveal such a large fish after a 122-year absence from science shows that rivers still hold natural mysteries that necessitate awe, respect, and protection.

The RRCC partnership is a pioneering effort to recover a species proactively, without federal listing. The nonregulatory basis of the conservation approach shapes the RRCC initiative making broad participation possible and supporting shared commitment. Although challenging, the RRCC's voluntary, multi-stakeholder approach has been extraordinarily successful in accomplishing its activities and achieving its goals. Given the current political climate and fiscal constraints, creative nonregulatory partnerships may be the best approach for achieving conservation goals in the 21st century.

South Carolina
Department of
Natural Resources

Buy

Regulations

Google Search

South Carolina Rare, Threatened, & Endangered Species Inventory
Species Found In Barnwell County
Data Last Updated January 17th, 2006.

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	LEGAL STATUS
ALLIUM CUTHBERTII	STRIPED GARLIC	G3	S?	SC
AMPHICARPUM MUEHLENBERGIANUM	BLUE MAIDEN-CANE	G4	S?	SC
ANODONTA COUPERIANA	BARREL FLOATER	G4	S?	SC
ASTRAGALUS MICHAUXII	SANDHILLS MILKVETCH	G3	S?	SC
ASTRAGALUS VILLOSUS	A MILK-VETCH	G4	S?	SC
BAPTISIA LANCEOLATA	LANCE-LEAF WILD-INDIGO	G4?	S?	SC
CAREX DECOMPOSITA	CYPRESS-KNEE SEDGE	G3	S?	SC
CAROLINA BAY		G?	S?	SC
CARYA MYRISTICIFORMIS	NUTMEG HICKORY	G4	S1	RC
CLEMMYS GUTTATA	SPOTTED TURTLE	G5	S5	ST
COLONIAL WATERBIRD		G?	S?	SC
CONDYLURA CRISTATA	STAR-NOSED MOLE	G5	S3?	SC
CORYNORHINUS RAFINESQUII	RAFINESQUE'S BIG-EARED BAT	G3G4	S2?	SE
CROTON ELLIOTTII	ELLIOTT'S CROTON	G2G3	S?	SC
ECHINACEA LAEVIGATA	SMOOTH CONEFLOWER	G2	S1	FE/SE
ECHINODORUS PARVULUS	DWARF BURHEAD	G3Q	S2	SC
ECHINODORUS TENELLUS	DWARF BURHEAD	G5?	S?	SC
EGRETTA CAERULEA	LITTLE BLUE HERON	G5	S?	SC
ELEOCHARIS ROBBINSII	ROBBINS SPIKERUSH	G4G5	S?	SC
ELEOCHARIS TRICOSTATA	THREE-ANGLE SPIKERUSH	G4	SR	SC
ELLIPTIO CONGARAEA	CAROLINA SLABSHELL	G4	S?	SC
GAURA BIENNIS	BIENNIAL GAURA	G5	S?	SC
HALESIA PARVIFLORA	SMALL-FLOWERED SILVERBELL-TREE	G?	S?	SC
HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	G4	S2	FT/SE
HELENIUM BREVIFOLIUM	SHORTLEAF SNEEZEWEED	G3G4	S1	RC
HELENIUM PINNATIFIDUM	SOUTHEASTERN SNEEZEWEED	G4	S?	SC

HYLA AVIVOCA	BIRD-VOICED TREEFROG	G5	S5	SC
HYPERICUM ADPRESSUM	CREEPING ST. JOHN'S-WORT	G2G3	S1	RC
IPOMOPSIS RUBRA	RED STANDING-CYPRESS	G4G5	S?	SC
LAMPSILIS CARIOSA	YELLOW LAMPMUSSEL	G3G4	S?	SC
LAMPSILIS SPLENDIDA	RAYED PINK FATMUCKET	G3	S?	SC
LINDERA SUBCORIACEA	BOG SPICEBUSH	G2	S?	RC
LOBELIA BOYKINII	BOYKIN'S LOBELIA	G2G3	S?	SC
LUDWIGIA SPATHULATA	SPATULATE SEEDBOX	G3G4	S?	SC
MACBRIDEA CAROLINIANA	CAROLINA BIRD-IN-A-NEST	G2G3	S?	SC
MENISPERMUM CANADENSE	CANADA MOONSEED	G5	S?	SC
MONARDA DIDYMA	OSWEGO TEA	G5	S?	SC
MYRIOPHYLLUM LAXUM	PIEDMONT WATER-MILFOIL	G3	S2	RC
NEOTOMA FLORIDANA	EASTERN WOODRAT	G5	S3S4	SC
NESTRONIA UMBELLULA	NESTRONIA	G4	S2	SC
NOLINA GEORGIANA	GEORGIA BEARGRASS	G3G5	S?	SC
OXYPOLIS CANBYI	CANBY'S DROPWORT	G2	S1	FE/SE
PARONYCHIA AMERICANA	AMERICAN NAILWORT	G3?	S?	SC
PICOIDES BOREALIS	RED-COCKADED WOODPECKER	G3	S2	FE/SE
PLATANTHERA LACERA	GREEN-FRINGE ORCHIS	G5	S1	SC
PTILIMNIUM NODOSUM	HARPERELLA	G2	S1	FE/SE
PYGANODON CATARACTA	EASTERN FLOATER	G5	S?	SC
QUERCUS SINUATA	DURAND'S WHITE OAK	G5	S1	SC
RANA CAPITO	GOPHER FROG	G3	S1	SE
RHEXIA ARISTOSA	AWNED MEADOWBEAUTY	G3	S2	SC
RHODODENDRON FLAMMEUM	PIEDMONT AZALEA	G3	S2	SC
RHYNCHOSPORA INUNDATA	DROWNED HORNEDRUSH	G3G4	S?	SC
RHYNCHOSPORA TRACYI	TRACY BEAKRUSH	G4	S?	SC
SAGITTARIA ISOETIFORMIS	SLENDER ARROW-HEAD	G4?	S2	SC
SCIURUS NIGER	EASTERN FOX SQUIRREL	G5	S4	SC
SCLERIA RETICULARIS	RETICULATED NUTRUSH	G4	SR	SC
STILLINGIA AQUATICA	CORKWOOD	G4G5	S1	SC
TRAUTVETTERIA CAROLINIENSIS	CAROLINA TASSEL-RUE	G5	S?	SC
UTRICULARIA FLORIDANA	FLORIDA BLADDERWORT	G3G5	S1	SC
UTRICULARIA OLIVACEA	PIEDMONT BLADDERWORT	G4	S1	SC
UTTERBACKIA IMBECILLIS	PAPER PONDSHELL	G5	S?	SC
VALLISNERIA AMERICANA	EEL-GRASS	G5	S?	SC
VILLOSA DELUMBIS	EASTERN CREEKSHELL	G4	S?	SC
VILLOSA VIBEX	SOUTHERN RAINBOW	G4Q	S?	SC

For detailed location information about rare & endangered species, please contact Julie Holling .

[County Selection | DNR Heritage Preserves Home Page | SCDNR Home Page]

Rembert C. Dennis Building, 1000 Assembly Street, Columbia, SC 29201

South Carolina Rare, Threatened, & Endangered Species Inventory KEY

Return to species data...

STATUS - legal status:

FE -
Federal Endangered

FT -
Federal Threatened

PE -
Proposed for Federal listing as Endangered

PT -
Proposed for Federal listing as Threatened

C -
Candidate for Federal listing

NC -
Of Concern, National (unofficial - plants only)

RC -
Of Concern, Regional (unofficial - plants only)

SE -
State Endangered (official state list - animals only)

ST -
State Threatened (official state list - animals only)

SC -
Of Concern, State

SX -
State Extirpated

South Carolina Department of Natural Resources - Phone Numbers
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V-542 Scott and Crossman 1973

W.B. Scott * E.J. Crossman

FRESHWATER FISHES OF CANADA

Bulletin 184

Fisheries Research Board of Canada, Ottawa 1973

FRESHWATER FISHES OF CANADA

W. B. Scott* • E. J. Crossman

Department of Ichthyology and Herpetology

Royal Ontario Museum, Toronto

BULLETIN 184

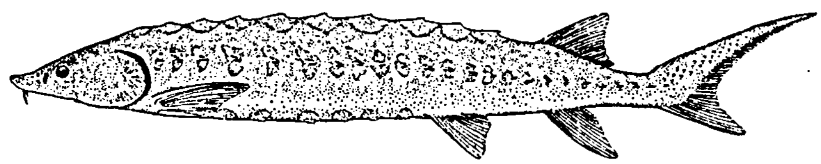
Fisheries Research Board of Canada, Ottawa 1973

Frontispiece: Lake Whitefishes

*Present address; Huntsman Marine Laboratory, St. Andrews, N.B., E0G 2X0.

SHORTNOSE STURGEON

Acipenser brevirostrum Lesueur



Description A moderate-sized, heavy-bodied fish, small compared to other sturgeons. Usual length 36 inches (912 mm). Body pentagonal in cross section. Head short, 22–28% of fork length, snout short, blunt, rounded, 70% of postorbital length in adults 15–28 inches (381–711 mm) but longer than postorbital length in young; mouth wide, width (excluding lips) 69–81% of interorbital width, no teeth; 4 barbels in front of mouth, somewhat closer to snout than to mouth; gill rakers moderately long, triangular, 22–29 (mean = 25.5) on first arch. Fins: single dorsal far back, opposite anal, trailing edge crescentric, 38–42 rays; caudal markedly heterocercal, lower lobe shorter and broad, upper long and pointed, no notch at lower tip, difference between fork length and total length is 11% of fork length; caudal peduncle short, tip of depressed anal reaching base of caudal fin; anal base about 60% of dorsal fin base, trailing edge emarginate, 19–22 rays; paired fins with heavy, ossified first ray, pelvics abdominal, far back, pectorals large. The body is not covered with scales but with patches of minute denticles and with rows of large, bony plates, scutes, or bucklers, 8–13 dorsal plates, 22–33 lateral plates, 7–11 ventral plates, at least 2 plates between dorsal fin and caudal fulcrum, at least one between anal fin and caudal fulcrum, usually a single row (sometimes 2 + 1) of plates between vent and anal fulcrum (preanal plates); no lateral line. Skeleton is cartilagineous except for membrane bones of skull, jaws, and pectoral girdle; vertebral centra absent, notochord persistent (largely from Vladykov and Greeley 1963).

Colour Body colour dark brown to nearly black on head, back, and sides to level of lateral plates, lighter brown to yellowish below, lower edge of head and body and entire ventral surface and barbels white; all fins pigmented but paired fins outlined in white; plates much paler and lateral plates obvious against dark background; viscera black, peritoneum pigmented; young with black blotches. Preserved specimens acquire a green colour in the skin, especially ventral surface and lower sides of head (Vladykov and Greeley 1963). A good colour illustration of an adult male was given (plate no. 2) in Greeley (1937).

Distribution Restricted to the eastern seaboard of North America from the Saint John River in New Brunswick to the St. Johns River of eastern Florida. Nowhere abundant now. It was probably most abundant, in the past, in rivers from the Connecticut to the Potomac.

In Canada it is known only from the Saint John River, upstream to Gagetown, where it is apparently more abundant than previously thought. Numbers of individuals in recent collections indicate the probable presence of a spawning population there. Records of the shortnose sturgeon in the St. Lawrence River were erroneous and based on *A. fulvescens* and *A. oxyrhynchus*.

Smith, et al. 2001

UJNR Aquaculture

30th Panel Proceedings (2001)

ECOLOGY OF AQUACULTURE SPECIES AND ENHANCEMENT OF STOCKS

V-543

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Link to Cover Page, Preface and Photo of Participants

Stock Enhancement Research with Anadromous and Marine Fishes in South Carolina

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Abstract

South Carolina's Marine Resources Research Institute (Department of Natural Resources) has been active in stock enhancement research since 1985. Initial efforts focused on a semi-anadromous endangered species, shortnose sturgeon *Acipenser brevirostrum*. Spawning, hatchery, and rearing techniques were developed using broodstock acquired from the Savannah River (the boundary river between South Carolina and Georgia), and over an 8-year period nearly 100,000 progeny (18.7% of which were tagged) were released back into that river. Stocking site, season, and fish sizes were varied in order to develop an optimal stocking protocol, and a number of studies were conducted to determine the best tagging method(s). A recent study designed to evaluate the success of the stocking program indicated that 38.7% of the adult population in the Savannah River is now comprised of stocked fish, and that the stocked fish have matured and are participating in spawning migrations. However, while wild fish generally do not leave their natal river, identifiable stocked fish have been captured in several other systems up to 278 km away from the mouth of the Savannah River. Data indicate that these wandering fish were almost exclusively individuals stocked at advanced ages and thus they may not have imprinted on the target river.

Since 1988, stock enhancement research has been conducted on a recreationally important and overfished sciaenid species, red drum *Sciaenops ocellatus*. Photothermal conditioning permits precise control of tank spawning in any season. Stocking studies, which are ongoing, have been conducted in a number of estuaries. It has been verified that fish stocked at a size >100 mm TL do appear in angler creels when they achieve the minimum legal size, but that they are relatively expensive to produce. Less expensive early age 0 (~2 mo, 20-55 mm TL) fish are now being stocked. They can be effectively marked, stocked, and their dispersal pattern determined. They also appear in angler creels in large numbers. Optimal stocking density has been estimated, and up to 78% of the legal fish in study areas have been identified as stocked fish. Controlled stocking in certain index areas has produced strong evidence that wild fish are supplemented rather than replaced by stocked fish.

A recent (2001) stock enhancement research program has been initiated for cobia *Rachycentron canadum*. About 1,500 tagged juveniles (~5 months old) were released into Port Royal Sound, SC, the estuary from which the broodfish were obtained. These were the first cobia stocked on the east coast of the U.S. This program has generated a great deal of interest from local angling clubs and fishing guides, and a number of these groups have provided labor and/or funds to assist the project. Near-term plans for research on this species include refinement of spawning methodology and growout techniques, as well as additional stocking activities. to elucidate early life history characteristics.

Introduction

South Carolina (SC) has been a pioneer in marine and estuarine stock enhancement research. Significant regional involvement dates to the mid-1960's and was focused on production of striped bass *Morone saxatilis* and its hybrids (especially white bass *M. chrysops* hybrids). The work was performed by staff of the Wildlife and Freshwater Fisheries Division of the South Carolina Department of Natural Resources (SCDNR). Development of a hormone based technique for spawning striped bass was a major breakthrough (Stevens, 1967) and formed the foundation for expansion of production activities. Although originally stocked to control gizzard shad *Dorosoma cepedianum*, the striped bass has become a premier freshwater game species. Based on the early work in South Carolina and neighboring states, striped bass and its hybrids are now stocked in estuaries, rivers, lakes and reservoirs throughout the United States (Bailey, 1975; Axon and Whitehurst, 1985).

Interest in stocking coastal rivers and estuaries began in 1985 with the establishment of a cooperative program between SCDNR and the United States Fish & Wildlife Service (USFWS). This program, conducted by the Marine Resources Research Institute (MRRI), Marine Resources Division, was broad based and examined the life history, ecology and potential for stock enhancement of the endangered shortnose sturgeon *Acipenser brevirostrum.* Stocking of this amphidromous fish occurred during the period 1984-1992, but funding for sampling to evaluate the success of the stocking program occurred only from 1990 to early 1993, and then again in 1997-2000. Fortunately, in the interim, other monitoring projects have provided substantial information on the occurrence and impacts of the stocked fish.

Decline in abundance of red drum *Sciaenops ocellatus* has been a major concern among fishery managers from the mid-Atlantic to the Gulf of Mexico for almost two decades. This species formerly supported substantial commercial and recreational fisheries from North Carolina (NC) through Texas (TX), and now all commercial fisheries have either been closed or severely restricted (Mercer, 1984; Matlock *et al.*, 1987; Goodyear, 1991; Wenner, 1992). Recreational anglers have also been impacted as evident by the increasingly restrictive size and creel limits that have evolved [1 fish/day in Florida (FL) and NC; 2 fish/day in SC]. In the most recent red drum virtual population analysis (VPA) the estimated escapement to spawning stock was 17% (Vaughan and Carmichael, 2000). This is an improvement over the previous estimate of 10% escapement in the 1993 VPA. However, even though escapement is slowly increasing, abundance of the population segment available to anglers (primarily subadults) appears to be declining, at least in SC (C. Wenner, SCDNR, Charleston, SC, personal communication). The current fisheries recruitment model suggests that a target escapement level of 40% is needed for a healthy population. Thus, it appears that full recovery of stocks through conventional management approaches will require a long time frame.

In 1988, MRRI initiated its first stock enhancement program with a marine species, red drum, to evaluate the use of hatchery fish as an additional management option. Initial stocking studies focused on use of larger juveniles which could be externally tagged. Results indicated that these fish survived and entered the creel of anglers as well as the adult population. Efforts then shifted to the use of smaller (~20-55 mm TL) juveniles that could be produced in larger numbers and at lower cost. These fish were marked with oxytetracycline-HCL (OTC) as well as genetically tagged. Using these smaller fish, it is now possible to stock 1–1.5 million/year as part of the research program, as compared to tens of thousands of larger fish.

During 2001, success in spawning and culturing cobia *Rachycentron canadum* has provided the opportunity to begin work with this highly migratory coastal species. This species, which has been reported to grow to a size of about 47 kg, inhabits most tropical, subtropical and warm temperate waters throughout the world (Shaffer and Nakamura, 1989). It is a prized game and valuable commercial species throughout its range. In spite of its high value as a seafood, landings are typically low and consist primarily of incidental captures. In the U.S. during 1998, combined landings from the Atlantic coast and Gulf of Mexico was approximately 150 mt with a value of about US $600,000 (Mills, 2000). Cobia inhabit SC waters during May to September (Bearden, 1961), but are absent during winter months. When here, they are the focus of specialty fishing, especially when aggregated for spawning. In conjunction with the local angling community, ~4-month old juveniles were tagged and stocked during fall 2001, around the time of their natural southern migration.

This manuscript provides a summary of the findings from the coastal stocking programs involving shortnose sturgeon, red drum and cobia.

Materials and Methods

General

The stocking programs were conducted under the auspices of MRRI. Stocking efforts were controlled as possible and performed in a fashion that has been described as the "responsible approach" by Blankenship and Leber (1995). In the case of the shortnose sturgeon, spawning activities took place at the Orangeburg National Fish Hatchery, SC (Smith, 1990; Smith and Jenkins, 1991; Smith *et al.*, 1993). Production of juveniles occurred at several USFWS hatcheries as well as MRRI's Charleston facilities and at the Waddell Mariculture Center (WMC), Bluffton, SC (Smith *et al.*, 1995). Red drum were spawned in Charleston and the juveniles produced in ponds at WMC (Smith *et al.*, 1999; 2001). Cobia spawning and production of juveniles occurred at WMC (Dodd, 2001).

Wild broodstock were used in all studies and were replaced during successive years of study. Released fish were marked and performance of marks/tags was documented. General health of fish was visually assessed before release. As possible, fish were held for several days to a week after marking to allow recovery before release into the wild. Samples from stocking groups were retained to assess tag retention or to validate biological marks, and to provide an estimate of post-stocking mortality. Tag recovery typically involved fishery independent as well as fishery dependent techniques. When external tags were used, tags contained reporting information as well as the offer of a reward.

Shortnose Sturgeon

The stocking research with shortnose sturgeon represents the first major effort in the U.S. with an acipenserid since the turn of the century. During 1984-1992, a state/federal program was conducted to evaluate the potential of enhancing/restoring populations of shortnose sturgeon through releases of hatchery reared fish (Smith and Jenkins, 1991; Smith *et al.*, 1995; Collins *et al.*, 1999). The Savannah River (Fig. 1) was chosen because ripe broodstock were obtainable but abundance of juveniles appeared low. A total of 97,483 sturgeon were stocked in the Savannah River. Of the fish released, 79,270 (81.3%) were untagged small juveniles (age 2-10 weeks, mean 41 mm TL, range 17-70 mm). They were stocked during 1984-1990 (except 1986). These fish were in excess of hatchery holding capabilities and were stocked in response to federal directives. In addition, 18,213 juveniles were marked and released during 1986-1992 (except 1987). These fish varied substantially in size (mean lengths of different groups ranged from 76 to 762 mm TL) and ages (2.5 months to 3 years old). The largest and oldest fish were extras to a program focused on development of domesticated breeding stock. The types of marks used varied as did the longevity of retention and detection (Collins *et al.*, 1994; Smith *et al.*, 1990; Smith *et al.*, 2002a).

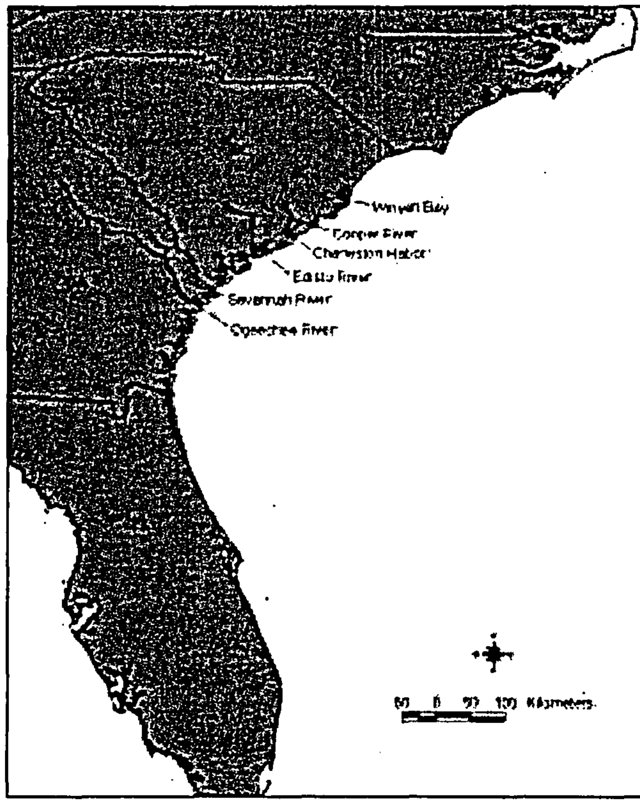

Figure 1. Map of Southeast United States showing locations where stocked shortnose sturgeon were captured.

Program components included examination of various stocking issues including: season of stocking; area of stocking; size of fish at stocking; retention and impacts of various marks; and movement of stocked fish (Smith *et al.*, 1995; Smith and Collins, 1996). Broodstock were obtained from the bycatch of the commercial American shad *Alosa sapidissima* gill net fishery and from directed sampling with gill nets and trammel nets. Directed sampling for stocked fish ended in January 1993, shortly after the stocking activities were concluded. Directed sampling in the Savannah River resumed during 1997-2000 using gill and trammel nets. In the interim, bycatch data collected from the commercial American shad fishery was used to monitor the population.

During 1994-2000, gill net collections targeting sturgeons and American shad were conducted in the Edisto River, SC (Smith *et al.*, 2002b) (Fig. 1). Sampling was limited to river kilometer (rkm) 23 to 36, but due to the limitations of the gear (drifting gill net with varying mesh sizes), rkm 28 was the primary sampling area. The area of rkm 28 typically coincided with the vicinity of the saltwater/freshwater interface. Besides this directed effort, commercial American shad fishers in the Edisto River had been keeping records of incidental captures of sturgeons since 1979. Shad fishers reporting sturgeon captures in the Edisto and other SC river systems typically used gill nets with 13.3 cm stretch mesh webbing, which effectively captured adult shortnose sturgeon. Bycatch information was also provided by participants in other fisheries (e.g., commercial shrimp *Penaeus* spp. trawl fishery). Directed sampling for sturgeons was also conducted in the Ogeechee River, Georgia (GA) (Fig. 1). During 1993-1998 (excluding 1996), 46 m long trammel nets (7.6 cm stretch inner and 38.1 stretch outer mesh) were used, while in 1999-2000, 27 m long anchored gillnets of varying mesh sizes (1.9 to 8.9 cm stretch mesh) were fished.

Red Drum

Research on red drum stock enhancement spans over a decade in SC. Initial work during 1988-1992 focused on identification of predictable spawning and juvenile production techniques and development of stocking protocols for juveniles (Smith *et al.*, 1992). Of substantial importance during this period was identification of tagging techniques for advanced juveniles and an evaluation of tag retention and reporting of tagged fish by anglers (Smith *et al.*, 1997; Jenkins *et al.*, 2000; Denson *et al.*, 2002). Evaluation of impacts was based on fishery independent (trammel netting) data coupled with fishery dependent (angler tag returns) data. During the mid-1990's, studies began to examine the impacts of stocking small red drum, as was being done in TX (Matlock, 1990; McEachron and Daniels, 1995; McEachron *et al.*, 1995; 1998). At this time, a chemical mark (OTC) was approved for use with red drum under an investigational new animal drug (INAD) permit issued by the U.S. Food and Drug Administration (FDA). Small fish could be more cheaply produced and thus more fish could be used in the stocking studies. Refinement of the marking technique was done and the retention of marks validated (Jenkins *et al.*, 2002). Small juveniles (20-45 mm TL) were produced in ponds out of season (May- June) and during the normal spawning season (August-October) and marked with OTC. After marking, fish were returned to a recovery pond for a week before stocking in Callawassie Creek, a tributary of the Colleton River and part of the Port Royal Sound estuary. This creek was located near the production facility. During 1995-1997, 1.7 million fish were released. Data on movements, contribution, growth, and sex composition were determined primarily from samples collected with trammel nets. Information obtained from trials conducted during spring 1995 are not included as marking, stocking, and sampling protocols were being developed during this period.

Current activities are examining the critical issue – "do stocked fish supplement a population or displace native fish." The Charleston Harbor estuary was selected for this study as there is an 8-year historical data base on red drum abundance based on a stratified random trammel net survey. Data were summarized for red drum less than 450 mm TL for nets set in 1 m depth or less water for the period July - December. Mean catch per unit effort (CPUE) for the Ashley River ranged from 0.3 to 1.4 fish/net set while the mean CPUE for the Wando River ranged from 1.2 to 8.4 fish/net set (Fig. 2).

These data support the hypothesis that the Ashley River has a much smaller population of age 1 red drum than does the Wando River. Due to the wide differences in the CPUE data, these two rivers were selected to examine the question of supplementation or displacement of wild fish by hatchery produced fish in a "degraded habitat" (Ashley River) and in a "healthy habitat" (Wando River). Fish were stocked over a 15 km reach of the river. The maximum potential nursery area was calculated over this distance using GIS technology. This calculation was made by adding the total coverage of *Spartina alterniflora* and the area of tributaries within the marsh while excluding the area covered by main river channel. Using this technique the stocked area of the Ashley River was estimated to contain a maximum of 980 ha of potential nursery area while the stocked area of the Wando River contained 2,903 ha. The Ashley River has been stocked for three years (1999-2001) with 617-687 fish/ha while the Wando River was stocked at a lower density of 118 and 177 fish/ha in 2001 and 2000, respectively (Table 1). Impacts are being evaluated based on recruitment of age 1 fish (~350 mm TL). Only results from the first year's stocking in the Ashley River are available.

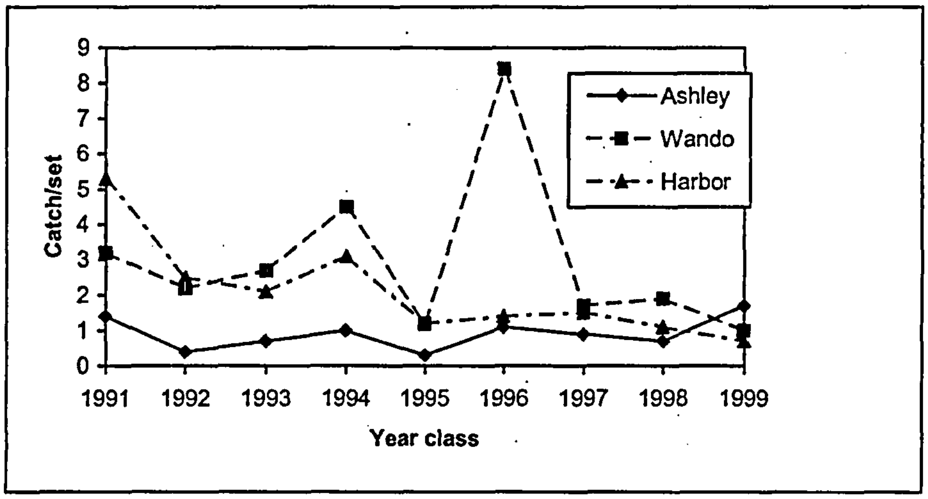

Figure 2. Random catch/unit effort data for age 11-16 month red drum collected in three areas of the Charleston Harbor estuary from each year class between 1991 and 1999. Hatchery fish (30 mm TL) were stocked in the Ashley River in the 1999 year class.

Table 1. Number released, mean total length and stocking density for red drum marked released each fall (Sept.- Nov.) in the Ashley and Wando Rivers between 1999 and 2001.

	Ashley River			Wando River		
Year	Number	Mean length (mm TL)	Density (n/ha)	Number	Mean length (mm TL)	Density (n/ha)
1999	617,190	30.0	630	-	-	-
2000	604,884	23.5	617	513,920	23.5	177
2001	673,751	20.8	687	344,949	20.4	118

Cobia

In the US, research with cobia has relied on field capture of wild fish as it has only been very recently that this species has been spawned in captivity and progeny produced (Sea Grant Virginia, 2000; Dodd, 2001; Arnold *et al.*, 2002). The spawning and culture successes in SC during 2001 produced advanced juveniles for research purposes. Interest in this species is three-fold: 1 – gain initial insights into the potential for stock enhancement; 2 – obtain basic information on the movements, growth, recruitment, and homing instincts of the species; and, 3 – examine its potential for commercial aquaculture. Work in all these areas is underway. During fall 2001, a total of 1,523 fish were tagged and released in four locations in Port Royal Sound through the combined efforts of local angling clubs (Hilton Head Island Sportfishing Club; Beaufort Sportfishing and Dive Club) and project staff. The fish were tagged with a dart tag and stocked on October 9 and 24 at which time they were 130-144 days old (Table 2). Overall, fish had a mean size of 347 mm TL and weighed 331 g. These pond-reared juveniles were produced during the normal spawning season and were similar in size to wild juveniles. Due to the high level of interest and involvement of recreational anglers and fishing guides, this program has been publicized along the south Atlantic coast (e.g. Florida Sportsman, Hilton Head Island Packet).

Table 2. Mean size (range) of 1,523, ~4 month old cobia juveniles tagged (dart tag) and released in Port Royal Sound, SC in 2001.

Release date (mth/da/yr)	Mean length (mm TL)	Mean weight (g)	Released (#)
10/09/2001	341 (235-390)	309 (178-443)	881
10/24/2001	356 (294-402)	362 (193-533)	642

Results and Discussion

Shortnose Sturgeon

This federal/state program was the first effort to evaluate the use of hatchery produced shortnose sturgeon as a potential management tool for supplementation or restoration of this endangered species. Information collected during the stocking efforts in the Savannah River and shortly thereafter indicated that stocked juveniles comprised a minimum of 35.4% of the juvenile population in the lower river nursery area (Smith and Collins, 1996). Based on recovery of marked fish after a mean time out of 7.2 ± 1.9 years (range 5.9-10.4) and results from double tagging studies, it is estimated that at least 38.7% of the adult population in the Savannah River during 1997-2000 was made up of stocked fish (Smith *et al.*, 2002a) (Table 3).

Table 3. Contribution of hatchery produced shortnose sturgeon to the adult populations of three coastal rivers between 1990 and 2000. Tag loss/non-detection factor of 3.72 not applied to the known hatchery origin data (fish contained marks). Data are means with range shown in parenthesis.

River (state)	Years data collected	Known hatchery origin (%)	Time at large (yrs)	Mean size (TL cm)
Savannah (GA)	1997-2000	10.4	7.2 (5.9-7.9)	77 (63-96)
Edisto (SC)	1995-2000	10.6	6.7 (4.1-10.2)	78 (58-98)
Ogeechee (GA)	1997-2000	8.4	7.4 (5.4-9.7)	80 (75-95)

Further, it was documented that stocked fish contained mature gametes and participated in spawning migrations (Smith *et al.*, 2002a). Population estimates and CPUE data from 1997-2000 suggest that the adult population is now larger than 10 years ago, but juveniles are still rare. This suggests that a recruitment bottleneck exists during the early life stages. From field sampling data, water quality degredation in the nursery habitat is believed to be at least partially responsible for the poor recruitment in the Savannah River (Smith *et al.*, 2002a).

Data on capture of tagged fish obtained from directed sampling and from commercial fisheries bycatch in other river systems have provided additional information on the fate of the fish stocked in the Savannah River. Beginning in 1995, hatchery fish began to be captured in non-target rivers, especially the Ogeechee River, GA, and Edisto River, SC, the two large rivers closest to the Savannah River (Figure 1, Table 3). From 1997-2000, identifiable stocked fish comprised 8.4% of the adult population in the Ogeechee River, while from 1995-2000, 10.6% of the adults in the Edisto River were identifiable as stocked fish (Smith *et al.*, 2002b) (Table 3). These values, as well as that for the Savannah River, can also be expanded (multiplied by 3.72) based on tag loss data from double tagging studies. In the Edisto River there was a historical Atlantic sturgeon fishery and shad fishery, the latter of which continues today. However, no shortnose sturgeon had been reported from the Edisto River prior to 1994. It appears that fish stocked into the Savannah River emigrated and colonized the Edisto River, and in 1998 the first age 1 juvenile was captured. In the Ogeechee River it appears that substantial supplementation of the population has occurred from the fish stocked in the Savannah River. Other stocked fish have been detected in the Cooper River, SC and in Winyah Bay, SC, a maximum of 278 km from the mouth of the Savannah River (Smith *et al.*, in press b) (Figure 1).

This stocking research identified issues associated with long term marking of stocked fish and showed that marking of small juvenile sturgeon for later recapture as adults was especially problematic. Improvement in tagging technologies, including use of genetic markers, should help resolve this issue. Stocking protocols approximated current recommendations developed by the

Atlantic States Marine Fisheries Commission (ASMFC) for Atlantic sturgeon (ASMFC, 1996) and were used in part to help develop these recommendations. However, stocking similar numbers of progeny per mating was not well controlled. This, coupled with assumed differential survival of different size groups of stocked animals, may have genetic implications relative to other river systems (Quattro *et al.*, 2002). Future stocking efforts need to strive for balanced numbers of progeny per broodstock mating and similar survival rates. As straying of some stocked fish into non-target rivers was noted, future shortnose sturgeon (and perhaps other species) stocking programs should address the issue of imprinting. Perhaps straying into non-target areas can be reduced by raising fish in target river water or by stocking very young (assumed pre-imprinting) fish.

Red Drum

With the apparent limited success of conventional fishery management regulations in maintaining healthy red drum populations, SC and other states are implementing or examining the use of hatchery release programs as an additional management tool. Texas has developed a large scale program which it feels is highly effective, and stocks approximately 40 million small juveniles per year (McEachron *et al.*, 1998). South Carolina and FL (Willis *et al.*, 1995) are conducting controlled studies to evaluate this approach, while other states (e.g. NC – Copeland *et al.*, 1998; GA – Woodward, 2000) have an interest but are evaluating the success of neighboring states.

Studies conducted to date in SC have identified suitable protocols for release (size, season, habitat, etc.) and have documented the survival and growth of stocked fish for periods up to 4 years post-release (Smith *et al.*, 1997). Chemical treatments for batch marking large numbers of small fish, as well as the use of external tags (abdominal T anchor) for individually marking larger fish, have been shown to be suitable for use in large scale field programs. However, both tagging methods have limitations; OTC requires sacrifice of the fish while external tags require use of large fish. Although stocking of large fish in Charleston Harbor, SC has resulted in a contribution to the local population of up to 4.1% (Table 4), production and stocking costs are major considerations (Smith *et al.*, 1997).

Table 4. Annual contribution of externally marked hatchery fish to the wild red drum population in the Wando River, SC between 1989 and 1994 (size at release ranged from 100–300 mm TL). Samples were collected randomly using a trammel net and include all ages and sizes of red drum captured each year.

Year	Stocked (#)	Fish sampled (#)	Hatchery contribution (%)
1989	4,145	897	0.8
1990	5,961	784	3.8
1991	11,279	1,209	0.3
1992	15,409	2,265	4.1
1993	14,957	2,496	1.3
1994	0	2,246	1.0

A total of 1,574,862 red drum juveniles (mean length 22 - 56 mm TL) were marked with OTC and released in Callawassie Creek, Port Royal Sound estuary, from fall 1995 to spring

1997. Using various gear types, 1,687 fish from target size groups were captured and sacrificed. In addition, 1,722 larger fish were captured, measured and released. Controlled studies with captive marked fish indicated that the OTC marks were visible for at least 52 months (Jenkins *et al.*, 2002). Results of analyses of otoliths indicated that there were no differences in growth rates of wild fish before or during the years that stocking occurred. Hatchery fish released in the fall grew at a rate similar to wild fish of the same year class (Smith *et al.*, 1999). Impacts of the stocked fish were evaluated over a 30 km distance from the stocking site. Sampling in the Port Royal Sound estuary of age 0 - 3 fish from the 1995 and 1996 year classes indicated that overall, hatchery fish comprised 19.4% (n=252) of the 1,316 fish collected from these year classes. Contribution to the local population at the release site increased as stocking number increased, with a maximum of 77.3% hatchery contribution recorded for the 1996 year class at Callawassie Creek, the stocking site (Fig. 3). However, in the estuary as a whole this proportional increase was not sustained, as the intermediate stocking number of 346,926 fish (1995) provided an overall contribution of 19.0%, which is similar to that recorded (19.7%) for the highest release number (1.2 million). Hatchery contribution decreased as fish aged, and fall hatchery fish (natural spawning time) appeared to make a larger proportional contribution than fish released out of season in the spring (Smith *et al.*, 1999). Hatchery and wild fish of various ages occupied similar habitats and were frequently captured in the same net sets. In addition, wild and hatchery-produced fish exhibited similar sex ratios (Smith *et al.*, 1999).

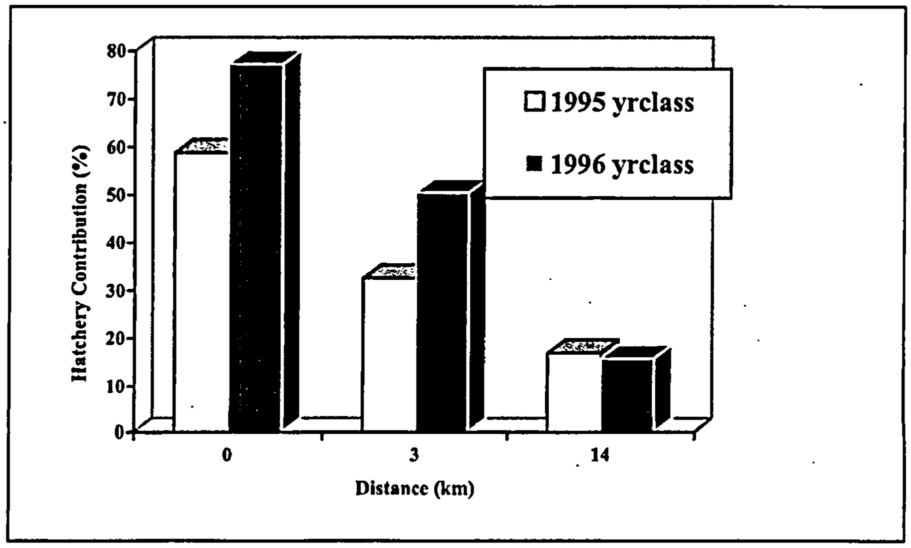

Figure 3. Percentage of all fish captured from each year class at each site between Summer 1996 and Spring 1999 which were of hatchery origin. The primary sample sites were the release site (0 km) Callawassie Creek; Rose Hill flats (3 km from release site) and the Chechessee River (14 km from release site).

The current phase of research is focused on the critical issue of supplementation vs. displacement. Stocked fish begin to recruit to the trammel nets used to sample the population at about 10 months of age, so only results from the 1999 stocking in the Ashley river are available. During December 2000 - February 2001, fish were taken (sacrificed) from the Ashley River to determine the percent contribution of stocked fish, as well as from Charleston Harbor and the Wando River to see if any movement had occurred. Based on OTC marked otoliths, stocking has had a significant supplemental impact on the Ashley River population (78% contribution) (Table 5) with the CPUE exceeding the highest level on record for this river (Table 6; Fig. 2). In fact, the Ashley River CPUE was the highest reported from any sampling site in the entire state, further demonstrating the depressed level of red drum stocks (Table 6). Besides the substantial impact on fish abundance in the Ashley River, a substantial portion of the fish in the Charleston Harbor estuary and a smaller portion of the fish in the Wando River were identified as originating from fish stocked in the Ashley River (Table 5).

Table 5. Hatchery contribution (%) to the 1999 year class of red drum as determined by both fishery independent and dependent sampling in the Ashley and Wando Rivers and Charleston Harbor. A total of 617,190 juvenile red drum were stocked in the Ashley River only.

	Fishery Independent		Fishery Dependent	
Site	Number sampled	Hatchery (%)	Number Sampled	Hatchery (%)
Ashley River	41	78	20	70
Wando River	51	12	3	0
Charleston Harbor	20	15	25	52

Table 6. Catch per unit effort in descending order for young of year red drum collected during random trammel net sampling along the coast of SC between July and December 2000.

Site	Effort (net sets)	Mean CPUE	Standard Deviation
Ashley River	41	1.73	3.7
Ace Basin	41	1.34	3.6
Muddy Bay	45	1.07	1.7
Wando River	32	1.00	2.4
Charleston Harbor	38	0.74	1.0
Romaine Harbor	46	0.63	1.3

These findings are quite dramatic and could have far reaching implications for SC and other states exploring the possibility of hatchery releases as a fishery management tool. However, data are from only the first year of this multi-year project and thus should be considered as preliminary. Additional annual stocking and data collection efforts in the Ashley and Wando Rivers will allow a time sequence of replication over which impacts can be assessed. This issue of supplementation vs. displacement has been identified as a priority concern and needs to be quantitatively addressed (Hilborn, 1999).

Cobia

There is limited information on the impacts of the stocked cobia in this new program. However, within a week of both stockings, there were anecdotal reports of a captured fish within the general release area. One fish was reported by an angler who was fishing in a tournament. He caught a tagged juvenile by hook and line but the fish was lost overboard before the tag details could be obtained. The second report came from a recreational shrimp baiter. While cast netting for shrimp at night he caught a cobia of the general size that had been stocked. No tag was noted before the fish was released. Both reports came from Port Royal Sound. A third fish was reported as being captured on October 27, 2001 in the surf at Cocoa Beach FL. This fish was from the October 9th release and had traveled approximately 480 km south during 18 days at large (26.7 km/day).

It is anticipated that during winter 2002 additional captures will be reported, as there is a suspected north-south movement pattern during fall along the southeastern U.S. (Hardy, 1978). In spring, fishermen have tracked the movement of adult cobia in the opposite direction (McNally, 1985). There is also a report of a wild cobia tagged off Charleston in June 1984 being recaptured off Biloxi, Mississippi in April 1986 (Shaffer and Nakamura, 1989). In SC, there have also been several reports of juveniles being captured in offshore waters during winter months suggesting an offshore movement (D. Hammond, SCDNR, Charleston, SC).

Little information exists on the population abundance of cobia. Recent VPA's on fish abundance in the Gulf of Mexico and along the Atlantic coast have been inconclusive due to a lack of sound modeling data (D. Hammond, SCDNR, Charleston, SC, personal communication 2001). However, it is felt that populations in the Gulf and along the south Atlantic have increased since the early 1980's. Information obtained from the stocking effort will provide new insights into the movements, growth, and potential for stock enhancement of this species.

Conclusions

South Carolina has made substantial progress in evaluating the utility of stock enhancement as a management tool. Although additional information is needed, the results to date suggest that release of hatchery fish may benefit depleted stocks. However, all efforts should be conducted in a responsible manner and stocking of hatchery fish should not be viewed as a substitute for strict habitat protection. Further, stock supplementation efforts should be coupled with conventional conservation/management actions to maintain the long term health of the populations.

Acknowledgments

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Staats 1983

V-045

THE IMPACT OF CONSTRUCTION OF VOGTLE ELECTRIC GENERATING PLANT ON THE AQUATIC MACROINVERTEBRATE POPULATIONS OF BEAVERDAM CREEK, JULY, 1973 THROUGH JUNE, 1978
OPERATING LICENSE STAGE ENVIRONMENTAL REPORT TECHNICAL DOCUMENT

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ENVIRONMENTAL AFFAIRS CENTER

APRIL, 1983

VEGP - OLSER

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INTRODUCTION

As required by Section 6.1.2.2 of the A. W. Vogtle Nuclear Plant Final Environmental Statement (March, 1974), an environmental study assessing the effect of plant construction activities on the resident aquatic fauna of Beaverdam Creek was begun by Environmental Affairs Center personnel on July 24, 1973. Aquatic macroinvertebrate populations were sampled during construction at approximately six-week intervals from July, 1973, through February, 1975. Sampling was discontinued from February, 1975, to May, 1976, while construction was halted. After construction resumed, sampling began in May, 1976, and continued through June, 1978. Quarterly visual inspections and water quality sampling will be conducted until the end of construction.

Section 4.3.2 of the FES suggested that construction activities could cause adverse effects on the Beaverdam Creek drainage basin receive runoff from the site. The FES further states that the major effect on the aquatic environment would result from the increased suspended particulate matter in the receiving waters.

Previous research suggested that increased suspended particulate matter from construction activities may affect aquatic fauna by habitat alteration, changing food availability (e.g. covering detritus), release of toxic substances, clogging of egg membranes and gills, smothering sessile benthic populations and inducing avoidance.[1, 2, 3] Several studies have shown that the number of organisms and species decreased downstream of sediment sources but recovered rapidly after the sediment load was reduced.[4, 5, 6, 7] In several cases, changes in species composition were noted with variable effects on numbers of individuals.[7, 8]

The purpose of this study was to determine the possible environmental effects of plant construction (erosion and siltation) on the aquatic macroinvertebrate community inhabiting Beaverdam Creek. The effects of siltation from access road construction and other land grading activities were also discussed.

METHODS

Beaverdam Creek is a fourth-order stream located in Burke County, Georgia, approximately six miles northwest of Girard and about 26 miles south-southeast of Augusta. The creek is approximately six miles in length and flows east-northeast to its confluence with the Savannah River. The area is characterized by rolling sandhills and mixed pine-hardwood association. The average yearly rainfall of the area is 39 inches (Bush Field, Augusta, National Oceanic and Atmospheric Administration). Two main tributaries of Beaverdam Creek are Daniels Branch, approximately five miles in length running southeast, and High Head Creek, one mile in length running northeast (figure 1).

Telfair Pond originated with the damming of Beaverdam Creek downstreem from the confluence of the three creeks. Seven sampling stations were located on Beaverdam Creek and Daniels Branch. The stations were designated: 2.0, 3.0, 3.5, 4.0, 6.0, 7.0, and 8.0. Stations 2.0, 3.0, and 6.0 were downstream of and could have been effected by construction. These stations were considered to be "unaltered habitats". Stations 4.0 and 8.0 were termed "altered habitats," as they were downstream of the site construction, but were affected by road construction prior to plant construction. Stations 3.5 and 7.0 were in areas unaffected by construction and, therefore, termed "control stations."

Station 2.0: Beaverdam Creek approximately 1.5 miles upstream from the Savannah River and 66.0 feet downstream from the wooden bridge on River Road. Predominant vegetation was hardwoods, low shrubs, and a few grasses. The substrate was composed of sand with scattered areas of detritus. The creek was about 33.0 feet with a depth from 1.5 feet to 5.0 feet.

Station 3.0: Beaverdam Creek approximately 1.5 miles upstream from the Savannah River and 33.0 feet supstream from the wooden bridge on River Road. Predominant vegetation was hardwoods, low shrubs, and a few grasses. The substrate was composed of sand and scattered areas of detritus. The creek width was about 33.0 feet with a depth from 0.6 feet to 3.0 feet.

Station 3.5: Beaverdam Creek approximately 1.6 miles upstream from the Savannah River and 33.0 feet above the confluence of Beaverdam Creek and an unnamed tributary draining sediment retention basin No. 1. Predominant vegetation was hardwoods, shrubs, and grasses. The creek was braided in the area of the station; therefore, one channel (6.0 feet wide and 1.5 to 4.0 feet deep) was chosen for sampling. The substrate was composed of sand and detritus.

Station 4.0: Unnamed tributary from sediment retention basin No. 1 approximately 1.6 miles upstream from the Savannah River and about 33.0 feet downstream of the access road. Predominant vegetation was cattails, willows, and low shrubs. Algae growth was prevalent at this station since this area was exposed to full sunlight most of the day. The creek width was about 6.0 feet and was from 0.3 to 1.0 feet deep with a substrate composed of sand and silt.

Station 6.0: Daniels Branch approximately 0.5 miles upstream from Telfair Pond and about 81.0 feet downstream from Telfair Plantation Road. Predominant vegetation was mixed hardwoods, low shrubs, and grasses. Stream substrate was composed of sand, gravel, and a few scattered areas of detritus. The creek was about 9.0 feet wide and 1.0 to 3.0 feet deep.

Station 7.0: Daniels Branch about 0.5 miles upstream from Telfair Pond and about 30.0 feet upstream from the confluence of Daniels Branch and the unnamed tributary which drained the area of sediment retention basin No. 2. The predominant vegetation was mixed hardwoods with a few shrubs and grasses. The creek was about 6.0 feet wide and 0.6 feet to 3.0 feet deep. The substrate was composed of sand and detritus.

Station 8.0: Unnamed tributary from sediment retention basin No. 2 approximately 0.5 miles upstream from Telfair Pond and about 9.0 feet upstream from its confluence with Daniels Branch. The predominant vegetation was mixed hardwoods with a few shrubs and grasses. The tributary was about 3.0 feet wide and 0.3 feet deep with a sand substrate.

In 1972 and early 1973, prior to the beginning of the study, an access road was built into the plant site. Stations 4.0 and 8.0 were located within 30.0 feet and 450 feet, respectively, of the access road. In September, 1977, a private logging operation upstream of Station 7.0 (a control), caused increased sediment loads resulting in reduced flow, braiding of the creek channel, and increased turbidity.

Aquatic macroinvertebrates were collected from Stations 2.0 through 4.0 and 6.0 through 8.0 at approximately six-week intervals from September, 1973, through February, 1975. All construction activities were suspended for the remainder of 1975 and the survey was discontinued. In 1976, construction resumed and the objectives of the sampling program were reevaluated. As a result, Stations 3.0, 4.0, 6.0, 7.0, and 8.0 were sampled in May, June, and August of 1976. Station 2.0 was discontinued because it was located within 90.0 feet of Station 3.0 and provided unneeded duplication. In March, 1977, sampling resumed at Stations 3.0, 4.0, 6.0, 7.0, and 8.0. At this time, Station 3.5 was added as an additional control in the vicinity of Stations 3.0 and 4.0. Station 8.0 was discontinued in July, 1977, because flooding caused the creek channel to move and the substrates were out of water. It was determined that it was futile for sampling to continue at Station 8.0 where flooding was common. Stations were sampled until June, 1978. Surveillance continues with a quarterly inspection and water quality sampling at each station.

On each sampling date, four Ekman grab samples (Ekman samples) and three Hester-Dendy multiplate samplers (Dendy samplers) were collected from each station. The Ekman samples were collected along a transect between banks. Ekman samples were washed in a No. 30 field screen and placed in liter jars. The three multiplate samplers were attached to an aluminum rod for easier handling. Immediately prior to removal from the water, the Dendy samplers were covered with nylon bags to prevent loss of macroinvertebrates. After retrieval, a replacement rod was placed at the station. All samples were preserved in ten percent formalin and transported to the laboratory.

In the laboratory, Ekman samples were stained with Rose-bengal and washed through a No. 30 U.S. standard soil sieve. Macroinvertebrates and detritus were brushed gently from artificial substrates and washed through a No. 30 sieve. Macroinvertebrates were sorted from detritus and sand using an illuminated magnifier and forceps. Identifications were made using a stereo-zoom microscope. Macroinvertebrates were identified to the lowest practical level.[9 through 14]

Macroinvertebrate data were arranged in groups according to sample date and assigned a seasonal period (table 1). The months used in each seasonal period may or may not correspond to traditional seasons, but the periods were incorporated to place the data in an order that would be familiar to the reader. In addition, combining data into periods provides "replicate" samples for analyzing the variance and distribution of the data.

Macroinvertebrate data from Ekman samples and Dendy samplers were stored on magnetic tape using the Southern Company Services, Inc., IBM computer system. The Shannon-Weiner diversity index (HBAR), total number of individuals (NUM-IND), and number of taxa (NTAXA) were tabulated using SAS 76.6. The Shannon-Weiner diversity index was calculated for each sample as:

$$\mathrm{HBAR} = \sum_{i=1 \text{ to } T}^{T} Pr_i \log_2 (Pr_i)$$

Where T = Number of taxa (NTAXA) and

Pr_i = Proportion of individuals in the i-th taxa[15]

Water samples, instantaneous air and water temperature, pH, and dissolved oxygen, measurements were obtained during each collection of macroinvertebrates. The water samples were analyzed according to Standard Methods[16] by Georgia Power Company's Central Laboratory.

Beginning in April, 1976, instantaneous discharge measurements were made in Beaverdam Creek and Daniels Branch at Stations 3.0, 3.5, and 6.0. At each station, the creek was divided into equal segments across the stream. Width and depths of each segment were recorded and used to determine cross-sectional areas. Velocity measurements were made using a Gurley Hydrological Instrument's Inc., pygmy-type current meter. An instantaneous discharge was calculated from the cross-sectional area and mean velocity. Stations 4.0, 7.0, and 8.0 were braided; therefore, flow measurements were not made.

Samples for total suspended solids were collected using a depth-integrating suspended sediment wading-type sampler, U.S. DH-48. Two suspended sediment samples were collected at Stations 3.5 and 6.0, and one sample was collected in each segment of the creek at Station 3.0. Instantaneous suspended sediment load (tons per day) was calculated using average suspended sediment (mg/l) and instantaneous discharge.

In order to determine the amount of bedload discharge, a sample of the bed material was collected and analyzed for grain size. The Schoklitsch formula was used for bedload determinations.[17] The Schoklitsch formula is:

$$G_1 = 156.2\ S^{3/2}\ (Q_0 - Q_{01})$$

Where G_1 is the bedload in lbs/sec/ft

S is the slope

Q_0 is the stream discharge in ft^3/sec

Q_{01} is the critical discharge or flow responsible for sediment transport along the channel bed in ft^3/sec

$$Q_{01} = \frac{1.088\ D^{3/2}}{S^{7/6}}$$

Where D is the particle diameter in feet

The slope of the creek bed at Stations 3.0, 3.5, and 6.0 were obtained from USGS quadrangle maps.

A seasonal qualitative analysis of species composition of each station was made using the more frequent or "significant" taxa. This type of comparison makes use of the biological information on community composition which is not reflected in numbers of individuals, numbers of taxa, and to a certain extent, taxonomic diversity indices. The objective is to base interpretations on those organisms that have a high probability of being collected during sampling and eliminate those which may be migrants from other localities or are too infrequent for statistical evaluation.[18]

The criteria[18] for selection of "significant" taxa were those used by Chutter:

1. Taxa composing five percent or more of the individuals in single samples, regardless of the number of samples in which they were found, and

2. Taxa found in more than half the samples collected in a period, regardless of their number.

The first criteria was evaluated using the total number of individuals excluding Oligochaetes and chironomids, since a preponderance of individuals in these two groups eliminated less numerous taxa. This criteria selected those taxa present in large numbers, but may be collected for a short period. The second criteria selects those taxa which may be present in low numbers but were collected with some frequency.

The statistical analysis considered the data in two parts: 1973 through 1974 and 1976 through 1978, due to changes in stations sampled and absence of data from most of 1975. The effect of year and month on the sample statistics could not be examined due to the variable frequency of sampling. Instead, the data were combined into three-month periods (approximating seasons) and analyzed for differences among stations. Variables analyzed were: Shannon-Weiner diversity index (HBAR); $\log_{10}$ transformation of the total number of individuals (LOG_{10} (N + 1)); and number of taxa (NTAXA). Assumptions of normality and homogeneity of variances were tested using the G-test and an approximation of the F-max test, respectively.[19] These sample statistics were generated using the KSLTEST procedure of SAS 76.6. An analysis of variance was performed on the sample statistics using the General Linear Models (GLM) procedure of SAS 76.6.[20] A two-way fixed effects model with replication was used to test for differences among stations and periods for HBAR, NTAXA, and LOG_{10} (N + 1). Type III estimable functions were used in computing sums of squares because of missing data and unequal numbers of observations. The statistical analysis and average values for HBAR, LOG_{10} (N + 1), and NTAXA are presented in Appendix A.

RESULTS AND DISCUSSION

Environmental components of each station, such as substrate type, stream width, stream depth, current velocity, and vegetation cover, affect its faunal composition. In order to determine the effects of perturbation, the physical make-up of each station should be duplicated as closely as possible.[7] The Beaverdam Creek stations were chosen to monitor sediment-induced perturbations, but faunal differences due to other physical factors were present.

Table 2 lists the macroinvertebrate taxa and total numbers of individuals found at stations in Beaverdam Creek. The letter code ("E" = Ekman, "D" = Dendy samplers) represents the sampler type that the organism was collected by and occurs only where a particular taxa met the criteria for "signicance."

The "significant" taxa unique to the Ekman or Dendy samplers reflected the habitats sampled by these techniques. During the survey, some of the "significant" taxa were collected by either or both samplers, but the organisms were not collected in great enough numbers or frequency to meet the criteria for "significance" in both samplers.

One hundred and fifty-three taxa were collected in Beaverdam Creek during the study. The most abundant included *Stenonema* spp., *Cheumatopsyche* spp., Ceratopogonidae, Chironomidae, Oligochaeta, and Pelecypoda. Of the 153 taxa, 126 were considered "significant." Forty-two taxa were "significant" in Ekmans only and 27 taxa were "significant" in Dendy samplers only. Sixteen taxa were "significant" at all stations when one or both of the sampling techniques were considered. Fifteen taxa were "significant" at Station 4.0 only, and four taxa were "significant" only at Station 8.0. Generally, a majority of the remaining "significant" taxa were shared by Stations 2.0, 3.0, 3.5, 6.0, and 7.0 and occasionally Stations 4.0 and 8.0.

Table 3 shows the number of "significant" taxa in Ekman samples for each station. The greatest number of "significant" taxa recorded was 36 at Station 3.5 during the spring, 1977. The least number of "significant" taxa (4) recorded was at Stations 4.0 and 8.0. It is evident that there was an increase in the number of "significant" taxa after summer, 1974.

Those organisms that were "significant" in Ekman samples only were inhabitants of the sediment or in close association with the bed of the creek. Examples include: *Baetisca* spp., *Hexagenia* spp., *Dromogomphus* spp., *Gomphus* spp., *Nectopsyche* spp., *Molanna* spp., Tabanidae, and *Corbicula* spp., most of which are burrowers or live in leaf packs and debris feeding as predators, detritivores, or filter feeders.[10, 12, 21, 22]

Table 4 gives the number of "significant" taxa at each station for Dendy samples. The greatest number of "significant" taxa at any station was recorded at Station 6.0 (23) and the least at Station 3.0 (1). Station 2.0 had the highest mean number of "significant" taxa (15.4) and Station 8.0 had the lowest (6.4). Stations 3.0, 6.0, and 7.0 had consistently higher numbers of "significant" taxa throughout the survey. Station 4.0

had low numbers during the fall, 1973, and winter, 1974; increased to control station levels in the spring, 1974, through summer, 1977; and decreased again during winter through summer, 1978. Generally, the number of "significant" taxa at Station 8.0 remained low throughout the time of sampling. The "significant" taxa found only in the Dendy samplers typically inhabit undercut banks, sticks, and debris or the surface of logs and rocks. These organisms include: Acroneuria spp., Corydalus spp., Nigronia spp., Macronema spp., and others. These species are either predatory or collector filter feeders. A majority of the organisms that were "significant" at all stations were tolerant of widely fluctuating environmental conditions. Tolerant taxa include: Cheumatopsyche spp., Macronychus spp., Ceratopogonidae, Chironomidae, and Oligochaete.[7, 21]

The "significant" taxa present in either sample type at all stations except 4.0 and 8.0 were: Hexagenia spp., Phylocentropus spp., Nectopsyche spp., and Ectopria spp. The above taxa require a stable or firm substrate which was not present at either Station 4.0 or 8.0.[12, 14, 21, 23]

Access road construction in 1972 eliminated all terrestrial and aquatic vegetation in the area of Station 4.0. The creek substrate was covered with a thick layer of silt (0.5 to 3 feet deep) which was very unstable. The succession of vegetation and stabilization of the substrate throughout the study created a unique habitat. Due to the habitat, different organisms were "significant" at Station 4.0 when compared to the other stations. The majority of "significant" taxa at Station 4.0 required slow-moving current with abundant algae and macrophytic vegetation.[12, 21, 22, 24] These taxa included: Hydropyrus spp. (Ephydra), Nemotelus spp., Cladocera, Ostracoda, Berosus spp., Nymphyla spp., and Habrophleboides spp. After the substrate at Station 4.0 began to stabilize (post-road construction), the area became overgrown with cattails (Typha latifolia) and willows (Salix nigra). Due to the presence of full sunlight most of the day, algal growth was prevalent at this station. No sediment movements were observed in the area of Station 4.0 after the substrate became stabilized, which indicates that on-site construction activities had no significant effect on the station. Station 8.0 was affected by road construction in the same manner as Station 4.0 with heavy silt cover (0.5 to 1.5 feet), but trees and shrubs were not removed. The stream channel at Station 8.0 shifted a minimum of three times during the survey, usually after heavy rains and flooding. The relative lack of macroinvertebrate species at Station 8.0 was probably due to channel movement and lack of bank vegetation. The four "significant" taxa unique to Station 8.0 were: (1) Calopteryx spp., (2) Tipula spp., (3) Bittacomorpha spp., and (4) Trematoda organisms preferring areas of decaying vegetation and detritus.[20, 21, 23] The majority of the above taxa were not found in "significant" numbers prior to the last two sampling periods. The establishment of these taxa late in the sampling program and their habitat preferences indicated that the creek bed was stabilizing.

The unaltered stations (2.0, 3.0, and 6.0) shared a majority of the "significant" taxa found at the control stations. This indicates that the unaltered stations were not adversely affected by plant or access road construction. In addition, the "significant" taxa data show that the altered stations (4.0 and 8.0) were generally different from all other stations. The colonization of the "significant" taxa at Stations 4.0 and 8.0 indicated that each station was not receiving large quantities of sediment from on-site construction.

The number of "significant" taxa for Ekman samples, shown in table 3, suggested that Stations 4.0 and 8.0 were similar to the control station in the fall, 1974. The fluctuations in numbers of "significant" taxa found at the unaltered stations were very similar to Station 7.0 throughout the survey. Indicating that the numbers of fauna at the unaltered stations were not changed by road or plant construction activities. From the spring, 1977, Station 3.5 had higher numbers of "significant" taxa than the other stations. The increased numbers at Station 3.5 were probably indicative of the favorable habitat. Recovery of organisms at the altered stations (4.0 and 8.0) occurred within a short time after the stream bed stabilized. Rapid faunal recovery of impacted stations has been reported by Tebo,[4] Gammon,[5] Reed,[6] and Lenat, et al.[7] The Dendy data in table 4 is variable but does show Station 8.0 having had low numbers of "significant" taxa a majority of the time. The low numbers of "significant" taxa at Station 8.0 were probably due to the substrate of shifting sand.

~~An increase in the numbers of "significant" taxa at the altered stations occurred after summer, 1974. The fauna at the unaltered stations were similar to the controls throughout the study.~~ It was recognized that the habitats at Stations 4.0 and 8.0 were changed and a majority of the "significant" taxa present were different from the other stations. The biological requirements of the taxa that were present demonstrated that the quality of habitat at Stations 4.0 and 8.0 did improve.

Since the Ekman samples were collected in a fixed-spatial design, the samples cannot be considered random. The assumption of spatial randomness is not applicable to the Dendy samplers since the entire sampler was counted. Results of the G and Fmax tests for HBAR, NTAXA, and Log_{10} (N + 1) collected in Ekman and Dendy samplers are presented in tables 5 through 8. The data were non-normal in many instances. A closer approximation of a normal distribution for total number of individuals was obtained using the following transformation:

$$LOG_{10}\ (N + 1) = \log_{10}\ (\text{NUM-IND} + 1)$$

The Fmax test demonstrated that the variances of the data were not homogeneous in specific cases (tables 7 and 8). Ekman samples obtained in 1973 through 1974 have significant differences among variances for LOG_{10} (N + 1) and NTAXA, but not for HBAR. Ekman samples collected during 1976 through 1978 showed significant differences among variances for NTAXA and HBAR values, but not for LOG_{10} (N + 1). Dendy samplers in 1973 through 1974 had significant differences among variances for LOG_{10} (N + 1) and NTAXA, but not for HBAR. Dendy samplers collected in 1976 through 1978 showed no significant deviation from the assumption of homogeneity for any variable.

An analysis of variance was completed recognizing that assumptions of normality and homoscedasticity were not met by the data. A two-way fixed effect model with replication was used to test for differences among stations and periods for HBAR, NTAXA, and LOG_{10} (N + 1) data. When no station-period interaction occurred and the variances of the data were homogeneous, further comparisons among mean values were made using the Bonferroni multiple comparison procedure.[25] Data obtained from Stations 2.0, 3.0, 3.5, 4.0, 6.0, 7.0, and 8.0 were used for this analysis.

The results of the analysis of variance are summarized in tables 9 and 10. Heterogeneous variances of station-period interaction precluded statistical comparisons among station means for LOG_{10} (N + 1) and NTAXA values for the 1973 to 1974. Multiple comparisons of station means for HBAR in 1973 to 1974 indicated that average values for the unaltered stations (2.0, 3.0, and 6.0) did not significantly differ from those obtained at the control station (7.0). Also, the mean values for the altered stations (4.0 and 8.0) were less than those obtained at the unaltered and control stations (see Appendix A-14).

Heterogeneous variances or station-period interaction also prevented statistical comparison among means from Dendy samplers collected during 1973 and 1974. Data obtained during 1976 to 1978 showed no significant differences among stations for LOG_{10} (N + 1) and HBAR. Significant station-period interaction ruled out further comparison among NTAXA for Dendy samplers collected in 1976 to 1978. No detectable differences were found among stations for data collected in 1976 through 1978.

The statistical analysis of Log_{10} (N + 1), NTAXA, and HBAR supported the previous conclusions based on species composition. The statistical analysis (Log_{10} (N + 1), NTAXA, and HBAR) for Ekman samples indicated that there were differences among stations, but these differences depend upon the time of year the sample was taken. This was expected since environmental changes have a varying effect on different habitats and the populations which inhabit them. Although a rigorous statistical analysis was not feasible, it is evident that Ekman samples collected in 1973 and 1974 had fewer individuals and taxa at the stations affected by road construction (4.0 and 8.0 of table 7). Multiple comparison among stations for species diversity supported this, indicating that Stations 4.0 and 8.0 were less diverse than the control (7.0) and unaltered stations (2.0, 3.0, and 6.0). Log_{10} (N + 1), NTAXA, and HBAR were not noticeably lower at Station 4.0 during 1976 through 1978. This suggested that this station had recovered from the impact of road construction by 1976.

Similar results were obtained from the Dendy samplers. Dendy samplers obtained during 1973 through 1974 had fewer individuals and NTAXA and lower HBAR at the altered stations compared to the control and unaltered stations. A statistical comparison among station means in 1973 through 1974 was not possible due to significant station-period interaction or heteorgeneous variances. Samples taken during 1976 through 1978 showed no significant differences among stations for LOG_{10} (N + 1) and HBAR. Differences among stations in NTAXA were significant but depended on the time of sampling. Thus, initial construction of the access road in 1972 adversely affected macroinvertebrates at Stations 4.0 and 8.0. Sampling during 1976 through 1978 indicated that these altered stations had recovered and were comparable in Log_{10} (N + 1) and NTAXA with stations unaffected by road construction.

Table 11 presents the mean, standard deviation, and coefficient of variation of physicochemical data collected from all stations and sampling dates. Seasonal divisions were not made.

Water temperatures at Stations 2.0, 3.0, 4.0, 6.0, and 8.0 were similar to those exhibited at Stations 3.5 and 7.0. Station 2.0 had the greatest variability (c.v. = 39.0%) in water temperature. The mean water temperatures for all stations ranged from a low of 17.3 C at Station 2.0 to a high of 19.5 C at Station 3.5.

Dissolved oxygen levels were within the same range for all stations. Stations 3.5 and 4.0 exhibited the greatest variation in dissolved oxygen with a coefficient of variation of 22.0 percent. The mean dissolved oxygen values ranged from a low of 7.6 mg/l (Station 4.0) to a high of 8.3 mg/l (Station 8.0).

Conductivity (μmhos/cm) values at the unaltered and altered stations were similar to those found at the control stations, except the variability was higher at Stations 3.0 and 4.0 (c.v. = 21.9% and 48.0%, respectively). The mean conductivity values for all stations ranged from a low of 35.6 μmhos/cm at Station 8.0 to a high of 86.0 μmhos/cm at Station 4.0.

Alkalinity values were similar for unaltered and control stations. Alkalinity values at Stations 4.0 and 8.0 varied more than the other stations (c.v. = 51.6% and 29.0%, respectively), while Station 2.0 had the least variation (c.v. = 10.2%). The values for alkalinity demonstrate the same general trends that were exhibited by conductivity with high mean value at Station 4.0 (35.4 mg/l) and a low mean value at Station 8.0 (13.9 mg/l).

The hardness values at Station 4.0 were higher than the control or other downstream stations. The greatest variation in hardness was exhibited at Stations 4.0 and 8.0 (c.v. = 52.0% and 77.3%, respectively), and Station 3.0 had the least variation (c.v. = 3.0%). Station 4.0 had the greatest mean hardness value (41.5 mg/l $CaCO_3$), while Station 8.0 had the lowest mean value (17.2 mg/l $CaCO_3$).

The unaltered and altered stations had approximately the same pH as the control stations throughout the study. Station 4.0 exhibited the greatest pH fluctuation (c.v. = 7.0%), while Station 3.5 showed the least variation (c.v. = 1.7%). The highest mean pH was obtained at Station 3.5 (7.2) and the lowest was at Station 8.0 (6.6).

Stations 4.0 and 8.0 exhibited greater turbidity than the control stations. Stations 2.0 and 3.0 were higher than and Station 6.0 was similar to the controls. Coefficients of variation for turbidity values were high at Stations 3.0 (161.0%), 4.0 (150.0%), and 8.0 (122.0%). Station 8.0 had the greatest mean value (33.8 NTU) and Station 3.5 had the lowest (3.0 NTU).

The total suspended solid data was similar to the turbidity data with Stations 4.0 and 8.0 having higher mean values than the other stations. The coefficient of variations for all stations were high with the lowest at Stations 3.0 and 3.5 (55.0% and 92.0%, respectively). Station 8.0 exhibited the greatest range (c.v. = 135.0%) in total suspended solids, while Station 3.0 showed the least (c.v. = 55.0%). The greatest mean value was obtained at Station 8.0 (45.6 mg/l) and Station 3.0 (5.48 mg/l) had the least.

Flow, total suspended solids, and suspended sediment discharge data are presented in table 12 for Stations 3.0, 3.5, and 6.0. It should be noted that Beaverdam Creek in the area of Station 3.5 was braided and only that portion of the stream that affected the Dendy and Ekman samples was monitored (approximately 15.0% to 20.0% of the total flow). Flow at Stations 3.0 and 3.5 did not fluctuate widely during the survey. However, at Station 6.0, flow was influenced by releases from sediment retention basin No. 2. The total suspended sediment data was used to calculate suspended sediment discharge. Suspended sediment discharge ranged from 0.12 to 0.82 tons/day at Station 3.0; 0.03 to 0.14 tons/day at Station 3.5; and 0.11 to 5.16 tons/day at Station 6.0. The high suspended sediment discharge at Station 6.0 on April 13, 1977, was probably due to high flow and high suspended solids for that date and would not be indicative of normal conditions.

Table 13 lists the results of the Schoklitsch formula applied to the data collected at Station 3.0. The estimated bedload discharges ranged from 140 tons/day on July 12 to 510 tons/day on May 7, 1976 and 1978, with an average value of 244 tons/day. It should be noted that these values are approximations.

Table 14 lists the results of the Schoklitsch formula applied to the data collected at Stations 3.5 and 6.0, respectively. The bedload discharges at Station 3.5 ranged from 5 tons/day to 16 tons/day. The bedload discharges at Station 6.0 ranged from 150 tons/day to 780 tons/day.

The physicochemical data (table 11) collected during the study were typical of natural waters and did not vary drastically from the control station data.[25, 27] Generally, conductivity, alkalinity, and hardness had the greatest variation at Stations 4.0 and 8.0. This was probably resulted from excavation on the plant site. Leaching of the soil components can cause differences in the stream chemistry.[27, 28] The mean turbidity was greater at Stations 4.0 and 8.0 (34.3 NTU and 46.0 NTU, respectively) but more variable at Station 3.0 (mean 5.6 NTU, c.v. of 130.0%).

Total suspended solids data had the greatest mean values at Stations 4.0 (30.6 mg/l) and 8.0 (53.5 mg/l) and the greatest variation at Station 7 (144.0%). Mean values for the other stations were a great deal lower ranging from 4.5 mg/l at Station 3.5 to a high of 15.8 mg/l at Station 6.0. It should be noted that the turbidity and total suspended solids data were extremely variable due to the nature of the drainage basin, the sediment input from access road and plant construction, and sampling variability. Table 12 shows low concentrations of suspended material at Stations 3.0, 3.5, and 6.0; therefore, it would be expected to have a small percentage of suspended load as compared to total sediment discharge. The data collected indicated the suspended sediment discharge to be less than one percent of the estimated total sediment discharge of Beaverdam Creek.

Most of the sediment discharge in Beaverdam Creek occurred as bedload movement. The bedload movement was characterized by sand particles rolling or tumbling along or near the streambed. This area was known as the unsampled zone.[29] Empiracal formulas must be used to estimate the amount of sediment discharge occurring within this unsampled zone. The most important factor in the amount of sediment discharge from Beaverdam Creek would be the influence of localized heavy rainfall. The resulting increased flow would increase the amount of bedload movement and greatly increase the amount of suspended materials.

CONCLUSIONS

Species composition at the unaltered stations were similar to the control stations throughout the study indicating that plant construction had little or no effect on the macroinvertebrate fauna of Beaverdam Creek.

Species composition at the altered stations (affected by access road construction) became increasingly similar to that of the control stations after the summer of 1974. This indicated that the altered stations recovered from access road construction and were not affected by plant construction.

The control stations generally had more taxa present than the altered stations due to the more stable substrate at the control stations.

Differences among stations for $LOG_{10}(N + 1)$ and HBAR were not signficant during 1976 through 1978. This suggested that initial differences among stations were largely due to access road construction, and that plant construction had little impact on the indices used. Significant differences among stations for NTAXA values probably reflected differences in habitat at specific stations.

Physicochemical data showed differences in conductivity, alkalinity, and hardness between the control and unaltered and altered stations. The variation in values at Stations 4.0 and 8.0 were probably due to the exposed soils on the plant site.

Suspended sediment data indicated that most of the sediment discharge in Beaverdam Creek occurred as bedload. The on-site sediment retention basins would cause heavier particles to settle out and be deposited in the basin; therefore, the bedload movement results from natural phenomena and not plant construction.

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TABLE 1

PERIOD DESIGNATION, YEAR AND MONTH OF SAMPLING, AND STATIONS SAMPLED DURING EACH SURVEY IN BEAVERDAM CREEK (* = STATION 3.5 WAS SAMPLED).

Period	Year	Month	Station Sampled
Fall	73	9	2.0 - 8.0
	73	10	2.0 - 8.0
	73	11	2.0 - 8.0
Winter	74	1	2.0 - 8.0
	74	2	2.0 - 8.0
Spring	74	4	2.0 - 8.0
	74	5	2.0 - 8.0
Summer	74	7	2.0 - 8.0
	74	8	2.0 - 8.0
	74	9	2.0 - 8.0
Late Fall & Winter	74	11	2.0 - 8.0
	74	12	2.0 - 8.0
	75	2	2.0 - 8.0
Summer	76	5	3.0 - 8.0
	76	6	3.0 - 8.0
	76	8	3.0 - 8.0
Spring	77	3	3.0 - 8.0*
	77	4	3.0 - 8.0*
	77	5	3.0 - 8.0*
Summer	77	7	3.0 - 7.0*
	77	8	3.0 - 7.0*
	77	9	3.0 - 7.0*
Fall	77	11	3.0 - 7.0*
Spring	78	2	3.0 - 7.0*
	78	3	3.0 - 7.0*
Summer	78	4	3.0 - 7.0*
	78	6	3.0 - 7.0*

TABLE 2 (Page 1 of 5)

AQUATIC MACROINVERTEBRATE FAUNA COLLECTED AT STATIONS IN BEAVERDAM CREEK WITH SPECIAL REFERENCE TO "SIGNIFICANT" TAXA. (D = SIGNIFICANT TAXA COLLECTED IN DENDY SAMPLES: E = SIGNIFICANT TAXA COLLECTED IN EKMAN SAMPLES).

	Stations							
	2.0	3.0	3.5	4.0	6.0	7.0	8.0	Total Number
Ephemeroptera			E	E	E			18
Siphlonuridae			E					2
Ameletus spp.	E							1
Isonychia spp.	D	D	D		D/E	D	D	364
Baetidae		E		E	D/E	E		33
Baetis spp.	D	D/E	D/E		D/E	D/E	D/E	228
Centroptilum spp.	D							4
Pseudocloeon spp.	D/E					D/E		20
Heptageniidae		D			D			10
Heptagenia spp.								1
Stenacron spp.					D			10
Stenonema spp.	D/E	D	D/E	D	D/E	D/E		2469
Leptophlebiidae								1
Habrophlebiodes spp.				E				1
Leptophlebia spp.	D				D	E		6
Paraleptophlebia spp.	D	D		D				13
Ephemerellidae								
Ephemerella spp.	D/E	D/E	D/E	D/E	D	D/E	D	257
Tricorythidae								
Tricorythodes spp.	D/E	D	D/E	D	D	D/E		161
Neoephemeridae								
Neoephemera spp.	E		D/E		D	E		20
Caenidae			E					1
Brachycercus spp.		E	E					14
Caenis spp.	D	D	D/E	D/E	D/E	D/E		143
Baetiscidae								
Baetisca spp.		E	E					5
Ephemeridae								
Hexagenia spp.	E	E	E		E	E		32
Odonata								1
Zygoptera								2
Calopterygidae								1
Calopteryx spp.							D/E	4
Hetaerina spp.						D		10
Coenagrionidae								2
Argia spp.	D	D		D	D			40
Enallagma spp.								2
Ischnura spp.								2
Agrionidae								5
Anisoptera					D			1
Cordulegastridae								
Cordulegaster spp.								1

TABLE 2 (PAGE 2 OF 5)

	Stations 2.0	3.0	3.5	4.0	6.0	7.0	8.0	Total Number
Gomphidae	E		E		E	E		17
Dromogomphus spp	E	E	E	E	E	E	E	147
Gomphus spp.		E	E	E	E	E	E	45
Hagenius spp.								2
Ophiogomphus spp.						E		1
Progomphus spp.		E	E		E	E	E	14
Aeschnidae								
Aeschna spp.	D							2
Boyeria spp.		D						8
Libellulidae	E	E			D/E			9
Macromia spp.		E	E	E	E			16
Neurocordulia spp.								3
Somatochlora spp.								1
Orthemis spp.								1
Plecoptera		D		D	D	E	D/E	45
Taeniopterygidae								
Taeniopteryx spp.		D				E	E	10
Nemouridae				D				9
Pteronarcidae								
Pteronarcys spp.								1
Perlidae		D	D/E	D	D	D		25
Neoperla spp.								1
Paragnetina spp.	D	D	D	E		D	D	29
Acroneuria spp.	D	D	D	D	D	D	D	89
Perlesta spp.	D	D	D/E		D/E	D/E	D	181
Atoperla spp.				D				2
Perlinella spp.				E				3
Perlodidae								2
Isogenus spp.		D	D			D		6
Isoperla sp.p.		D	D/E		D			24
Hemiptera				E				1
Corixidae					E			3
Veliidae					E			1
Microvélia spp.				E	E			2
Megaloptera								
Corydalidae								
Chauloides spp.			D					6
Corydalus spp.	D	D	D	D	D	D	D	61
Nigronia spp.				D	D			11
Sialidae								
Sialis spp.	D/E	D/E	D/E	D	D/E	E		45

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TABLE 2 (PAGE 3 OF 5)

	Stations							
	2.0	3.0	3.5	4.0	6.0	7.0	8.0	Total Number
Trichoptera			E	D	D/E			17
Philopotamidae								
Chimarra spp.	D	D			D	D		135
Psychomyiidae					D			5
Lype diversa		D	D		D		E	49
Polycentropodidae					D			7
Neureclipsis spp.	D/E	D/E	D		D			53
Polycentropus spp.	D/E	D/E	D	D	D/E			56
Phylocentropus spp.	E	E	E		D/E	E		150
Hydropsychidae		D/E	D/E	D/E	D	D/E	E	96
Diplectrona spp.				D				7
Cheumatopsyche spp.	D/E	D/E	D/E	D/E	D/E	D/E	D/E	1207
Hydropsyche spp.	D	E		D	D/E			26
H. incommoda	E	D		D/E	D	D/E		92
H. orris	D				D			5
Macronema spp.	D			D	D			21
Hydroptilidae				D/E	D			39
Brachycentridae	E		E					2
Brachycentrus spp.			E					8
Limnephilidae								
Pycnopsyche spp.			E			E		9
Neophylax spp.	E							2
Lepidostomatidae								
Lepidostoma spp.	E							2
Molannidae								
Molanna spp.		E	E	E				6
Leptoceridae								1
Ceraclea spp.			E		D			2
Mystacides spp.						D		1
Triaenodes spp.								1
Oecetis spp.	D/E	D/E	D/E		D/E			107
Nectopsyche spp.	E	E	E		E	E		125
Coleoptera				E				4
Dytiscidae								
Hydroporus spp.	E	E	E	D	D			16

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TABLE 2 (PAGE 4 OF 5)

	Stations							
	2.0	3.0	3.5	4.0	6.0	7.0	8.0	Total Number
Elmidae								
Ancyronyx variegatus	D/E	D	D	D/E	D			63
Dubiraphia spp.						E		3
Macronychus spp.	D/E	D/E	D/E	D	D	D/E	D	327
Microcylloepus spp.			D					6
Stenelmis spp.	E	D/E	D/E	D/E		D/E	D	144
Psephenidae								
Ectopria spp.	E	D	D/E		D/E	D		44
Gyrinidae								
Dineutus spp.	D							7
Gyrinus spp.								1
Haliplidae								
Peltodytes spp.								3
Hydrophilidae								
Berosus spp.			E					1
Hydrochus spp.								1
Chrysomelidae								
Donacia spp.					E			1
Lepidoptera				E				1
Pyralidae								
Nymphula spp.				E				1
Diptera				E				3
Tipulidae			E	E	D		D/E	10
Eriocera fultonensis								1
Tipula spp.							D/E	23
Ceratopogonidae	D	D/E	E	D/E	D/E	D/E	D/E	1730
Atrichopogon spp.								3
Chironomidae	D/E	D/E	D/E	D/E	D/E	D/E	D/E	32757
Simuliidae	E	D	E	D/E	D/E	D/E	D/E	183
Ptychopteridae								
Bittacomorpha spp.							E	1
Stratiomyidae								
Nemotelus spp.				D				1
Tabanidae		E		E	E	E		21
Hydrellia spp.								1
Psychodidae								1
Empididae	D/E	D/E	D/E	D/E	D	D/E	E	178
Ephydridae								
Hydropyrus spp. (*Ephydra*)				E				8

TABLE 2 (PAGE 5 OF 5)

	Stations							
	2.0	3.0	3.5	4.0	6.0	7.0	8.0	Total Number
Hydrozoa								
Hydra spp.	D/E	D			E			15
Turbellaria								
Planaridae	E	D/E	D/E	D/E	D/E	D/E		560
Rhynchocoela	E	E		E	E	D/E	E	83
Prostoma rubrum		D/E	D/E	D/E	D/E	D/E		827
Nematoda	E	E	E	D/E	D/E	D/E	E	974
Gordioidea			E					2
Oligochaeta	D/E	D/E	D/E	D/E	D/E	D/E	D/E	16545
Polychaeta								
Manyunkia spp.								1
Hirudinea	D	E	E	E	E	D	D	38
Cladocera				E				4
Ostracoda				D				3
Copepoda		E	E	D/E	D/E	D/E	E	83
Amphipoda	E		D/E	D		E	E	16
Collembola	E	E	E	E	E	E	E	560
Hydracarina	E	E	D/E	D	E			36
Acari				E				1
Mollusca								
Gastropoda	E	D/E	E	D/E	D/E	D/E	D/E	863
Ancylidae								
Lavapex spp.				E				7
Ferrissia spp.	E	D/E	D/E	D/E	D/E	E	E	166
Pelecypoda	D/E	E	E	D/E	D/E	D/E	D/E	6649
Corbicula sp.	E				E			2
Elliptio spp.	E					E	E	23
Trematoda							E	4

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TABLE 3

NUMBER OF SIGNIFICANT TAXA AT EACH STATION IN BEAVERDAM CREEK FOR EKMAN SAMPLES.

	Station						
	2.0	3.0	3.5	4.0	6.0	7.0	8.0
Fall 1973	20	14	-	11	14	15	4
Winter 1974	11	10	-	4	12	19	7
Spring 1974	17	10	-	4	12	16	6
Summer 1974	14	14	-	9	10	15	8
Fall 1974	24	21	-	14	20	17	18
Summer 1976	-	17	-	13	9	15	11
Spring 1977	-	16	36	12	12	12	12
Summer 1977	-	17	25	21	20	8	-
Fall 1977	-	5	18	7	7	14	-
Spring 1978	-	7	10	5	7	9	-
Summer 1978	-	9	13	8	8	8	-

- = No data obtained.

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TABLE 4

NUMBER OF SIGNIFICANT TAXA AT EACH STATION IN BEAVERDAM CREEK FOR DENDY SAMPLES.

	Station						
	2.0	3.0	3.5	4.0	6.0	7.0	8.0
Fall 1973	17	13	-	8	20	18	6
Winter 1974	15	16	-	6	5	10	12
Spring 1974	6	11	-	13	6	15	4
Summer 1974	18	17	-	18	18	11	5
Fall 1974	21	16	-	15	14	13	7
Summer 1976	-	20	-	17	10	9	6
Spring 1977	-	16	15	14	23	11	5
Summer 1977	-	11	17	15	16	9	-
Fall 1977	-	1	13	-	8	10	-
Spring 1978	-	10	8	9	5	8	-
Summer 1978	-	10	13	9	11	8	-
Mean Number	15.5	12.8	13.2	12.4	12.4	11.1	6.4

- = No data obtained.

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TABLE 5

PROBABILITY THAT DATA ARE NORMALLY DISTRIBUTED FOR EKMAN SAMPLES.

1973 - 1974

	LOG_{10} (N+1)		NTAXA		HBAR	
Station	$P\text{-}G_1$	$P\text{-}G_2$	$P\text{-}G_1$	$P\text{-}G_2$	$P\text{-}G_1$	$P\text{-}G_2$
2.0	0.029	0.697	0.659	0.574	0.045	0.716
3.0	0.808	0.286	0.134	0.314	0.136	0.437
4.0	0.282	0.994	0.006	0.753	0.007	0.248
6.0	0.711	0.416	0.413	0.213	0.359	0.266
7.0	0.009	0.947	0.977	0.135	0.123	0.231
8.0	0.612	0.889	0.000	0.000	0.340	0.205
Maximum	0.808	0.994	0.977	0.753	0.359	0.716
Minimum	0.009	0.286	0.000	0.000	0.007	0.205

1976 - 1978

	LOG_{10} (N+1)		NTAXA		HBAR	
Station	$P\text{-}G_1$	$P\text{-}G_2$	$P\text{-}G_1$	$P\text{-}G_2$	$P\text{-}G_1$	$P\text{-}G_2$
3.0	0.383	0.054	0.000	0.122	0.109	0.130
3.5	0.905	0.258	0.250	0.151	0.645	0.058
4.0	0.305	0.131	0.058	0.970	0.427	0.495
6.0	0.637	0.455	0.553	0.926	0.678	0.122
7.0	0.269	0.394	0.012	0.114	0.346	0.814
Maximum	0.905	0.841	0.553	0.970	0.678	0.814
Minimum	0.269	0.131	0.000	0.114	0.109	0.058

For $\alpha = 0.05$, $P > 0.95$ indicates that the data are normally distributed.

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TABLE 6

PROBABILITY THAT DATA ARE NORMALLY DISTRIBUTED FOR DENDY SAMPLERS.

1973 - 1974

Station	LOG_{10} P-G_1	(N+1) P-G_2	NTAXA P-G_1	NTAXA P-G_2	HBAR P-G_1	HBAR P-G_2
2.0	0.177	0.978	0.004	0.662	0.598	0.685
3.0	0.194	0.959	0.058	0.542	0.846	0.200
4.0	0.001	0.533	0.000	0.001	0.000	0.000
6.0	0.083	0.833	0.027	0.010	0.553	0.540
7.0	0.850	0.692	0.000	0.014	0.197	0.826
8.0	0.334	0.518	0.002	0.001	0.243	0.173
Maximum	0.850	0.978	0.058	0.662	0.846	0.685
Minimum	0.001	0.518	0.000	0.001	0.000	0.000

1976 - 1978

Station	LOG_{10} P-G_1	(N+1) P-G_2	NTAXA P-G_1	NTAXA P-G_2	HBAR P-G_1	HBAR P-G_2
3.0	0.000	0.054	0.660	0.881	0.789	0.586
3.5	0.000	0.000	0.822	0.921	0.906	0.440
4.0	0.179	0.373	0.021	0.083	0.107	0.874
6.0	0.001	0.295	0.665	0.525	0.014	0.495
7.0	0.041	0.829	0.795	0.445	0.752	0.996
Maximum	0.179	0.829	0.822	0.921	0.906	0.996
Minimum	0.000	0.000	0.021	0.083	0.014	0.440

For $\alpha = 0.05$, $P > 0.95$ indicates that the data are normally distributed.

TABLE 7

TESTS OF HOMOGENEITY OF VARIANCES FOR LOG_{10} (N+1), NTAXA, NAD HBAR FROM EKMAN SAMPLES.

1973 - 1974

		LOG_{10} (N+1)		NTAXA		HBAR	
Station	N	$\bar{X}$	S^2	$\bar{X}$	S^2	$\bar{X}$	S^2
2.0	44	1.44	0.20	5.82	13.08	1.58	0.56
3.0	48	1.38	0.30	5.19	10.37	1.34	0.58
4.0	48	0.91	0.49	2.25	3.38	0.47	0.37
6.0	48	1.31	0.22	3.92	4.16	1.12	0.35
7.0	48	1.38	0.18	4.60	6.80	1.23	0.41
8.0	48	0.98	0.21	2.69	2.99	0.91	0.35
Maximum S^2			0.49 N = 48		13.08 N = 44		0.58 N = 48
Minimum S^2			0.18 N = 48		2.99 N = 48		0.35 N = 48
Fmax			2.72*		4.37**		1.55 NS

* Significant for $\alpha = 0.05$, variances not homogeneous
** Significant for $\alpha = 0.01$, variances not homogeneous

1976 - 1978

		LOG_{10} (N+1)		NTAXA		HBAR	
Station	N	$\bar{X}$	S^2	$\bar{X}$	S^2	$\bar{X}$	S^2
3.0	56	1.73	0.24	4.96	13.93	1.00	0.64
3.5	56	1.81	0.23	8.81	15.69	1.50	0.71
4.0	56	2.05	0.21	6.25	5.25	1.33	0.27
6.0	56	1.70	0.15	5.02	3.00	1.32	0.23
7.0	44	2.20	0.17	8.77	9.27	1.71	0.19
Maximum S^2			0.24 N = 56		15.69 N = 56		0.71 N = 56
Minimum S^2			0.15 N = 56		3.00 N = 56		0.19 N = 56
Fmax			1.60 NS		5.23**		3.74**

** Significant for $\alpha = 0.01$, variances not homogeneous

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TABLE 8

TESTS OF HOMOGENEITY OF VARIANCES FOR LOG_{10} (N+1), NTAXA, AND HBAR FROM DENDY SAMPLERS.

1973 - 1974

		LOG_{10}(N+1)		NTAXA		HBAR	
Station	N	$\bar{X}$	S^2	$\bar{X}$	S^2	$\bar{X}$	S^2
2.0	32	1.37	0.39	6.28	15.05	1.68	0.72
3.0	30	1.51	0.14	6.93	9.37	1.86	0.47
4.0	30	1.20	0.50	4.17	16.14	0.77	0.67
6.0	30	1.11	0.31	5.83	16.70	1.67	0.93
7.0	33	1.48	0.49	8.88	33.92	1.95	1.27
8.0	27	1.00	0.36	3.07	8.38	0.90	0.56
Maximum S^2		0.50 N = 30		33.92 N = 33		1.27 N = 33	
Minimum S^2		0.14 N = 30		8.38 N = 27		0.47 N = 30	
Fmax		3.57**		4.05*		2.70 NS	

* Significant for α = 0.05, variances not homogeneous

** Significant for α = 0.01, variances not homogeneous

1976 - 1978

		LOG_{10}(N+1)		NTAXA		HBAR	
Station	N	$\bar{X}$	S^2	$\bar{X}$	S^2	$\bar{X}$	S^2
3.0	33	1.62	0.40	7.21	14.11	1.39	0.60
3.5	33	1.72	0.34	8.48	18.95	1.60	0.80
4.0	39	1.62	0.25	6.92	12.76	1.62	0.40
6.0	36	1.71	0.41	9.00	21.60	1.71	0.60
7.0	41	1.57	0.41	8.17	10.90	1.53	0.59
Maximum S^2		0.41 N = 41		21.60 N = 36		0.80 N = 33	
Minimum S^2		0.25 N = 39		10.90 N = 41		0.40 N = 39	
Fmax		1.64 NS		1.98 NS		2.00 NS	

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TABLE 9

RESULTS OF ANALYSIS OF VARIANCE FOR EKMAN SAMPLES. THESE RESULTS ARE SUMMARIZED FROM ANOVA TABLES 3, 4, 7, 8, 11, AND 12 IN APPENDIX A.

	1973-1974		1976-1978	
LOG_{10} (N+1)				
	Source	P	Source	P
	Station[1,2]	0.0001	Station[2]	0.0001
	Period	0.0083	Period	0.0001
	Station-Period	0.0015	Station-Period	0.0025
NTAXA				
	Source	P	Source	P
	Station[1]	0.0001	Station[1]	0.0001
	Period	0.0015	Period	0.0055
	Station-Period	0.5972	Station-Period	0.3632
HBAR				
	Source	P	Source	P
	Station[3]	0.0001	Station[1]	0.0001
	Period	0.0053	Period	0.3359
	Station-Period	0.6716	Station-Period	0.1659

1. Heterogeneous variances precludes comparison among mean values.

2. Significant station-period interaction precludes comparison among mean values.

3. Comparison among mean values indicate: 7 = 2, 3, 6 > 4, 8, (see Appendix A, Table 14).

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TABLE 10

RESULTS OF ANALYSIS OF VARIANCE FOR DENDY SAMPLES. THESE RESULTS ARE SUMMARIZED FROM ANOVA TABLES 16, 17, 20, 21, 24, AND 25 IN APPENDIX A.

	1973-1974		1976-1978	
	Source	**P**	**Source**	**P**
LOG_{10} (N+1)	Station[1,2]	0.0008	Station	NS (P < 0.1515)
	Period	0.0001	Period	0.0002
	Station-Period	0.0001	Station-Period	0.0001
NTAXA	Station[1,2]	0.0001	Station[2]	0.005
	Period	0.0116	Period	0.076
	Station-Period	0.01	Station-Period	0.0002
HBAR	Station[2]	0.0001	Station[1]	NS (P < 0.1245)
	Period	0.0194	Period	0.0096
	Station-Period	0.0593	Station-Period	0.0002

1. Heterogeneous variances precludes comparison among mean values.

2. Significant station-period interaction precludes comparison among mean values.

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TABLE 11

PHYSICOCHEMICAL DATA FOR SURVEYS FROM 1973-1978 ON BEAVERDAM CREEK (MEAN ± STANDARD DEVIATION) / (COEFFICIENT OF VARIATION)

	Station						
	2.0	3.0	3.5	4.0	6.0	7.0	8.0
Water Temperature (°C)	17.3 ± 6.7 / 39%	19.2 ± 6.5 / 34%	19.5 ± 6.6 / 34%	19.4 ± 7.0 / 36%	18.8 ± 6.3 / 34%	19.1 ± 6.1 / 32%	19.3 ± 7.0 / 36%
DO (mg/l)	8.0 ± 1.53 / 19%	7.9 ± 1.20 / 15%	7.7 ± 1.73 / 22%	7.6 ± 1.65 / 22%	8.0 ± 1.4 / 18%	8.0 ± 1.26 / 16%	8.3 ± 1.9 / 14%
Conductivity (μmhos/cm)	49.3 ± 4.6 / 9.3%	48.4 ± 10.6 / 21.9%	47.7 ± 3.3 / 6.9%	86.0 ± 41.0 / 48%	48.8 ± 4.3 / 9.0%	49.7 ± 5.84 / 12.0%	35.6 ± 6.2 / 17.0%
Alkalinity mg/l $CaCO_3$	21.8 ± 2.24 / 10.2%	22.1 ± 2.76 / 12.4%	22.7 ± 3.64 / 16.0%	35.4 ± 18.3 / 51.6%	20.4 ± 2.7 / 13.2%	21.6 ± 2.8 / 13.0%	13.9 ± 4.0 / 29.0%
Hardness mg/l $CaCO_3$	22.6 ± 2.0 / 8.0%	23.0 ± 2.69 / 3.0%	23.0 ± 1.9 / 8.0%	41.5 ± 21.7 / 52%	22.4 ± 3.4 / 15%	23.3 ± 3.4 / 15%	17.2 ± 13.3 / 77.3%
pH	6.9 ± 0.15 / 2.0%	7.0 ± 0.20 / 3.0%	7.2 ± 0.12 / 1.7%	6.8 ± 0.47 / 7.0%	6.9 ± 0.38 / 5.5%	6.9 ± 0.28 / 4.0%	6.6 ± 0.19 / 3.0%
Turbidity (NTU)	4.9 ± 5.2 / 106%	4.9 ± 7.9 / 161%	3.0 ± 1.6 / 54%	22.6 ± 33.9 / 150%	7.0 ± 3.6 / 51%	4.2 ± 2.62 / 63%	33.8 ± 41.4 / 122%
Total Suspended Solids (mg/l)	--	5.48 ± 3.0 / 55%	5.9 ± 5.4 / 92%	30.6 ± 40.5 / 132%	18.3 ± 22.0 / 120%	11.4 ± 14.9 / 130%	45.6 ± 61.5 / 135%
Number of samples	13	27	11	27	27	27	19

-- = No data obtained.

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TABLE 12

FLOW, TOTAL SUSPENDED SOLIDS, AND SUSPENDED SEDIMENT DISCHARGE AT STATIONS 3.0, 3.5, AND 6.0 IN BEAVERDAM CREEK.

	Station 3.0			Station 3.5			Station 6.0		
Date	Flow (CFS)	Total Suspended Solids (mg/ℓ)	Suspended Sediment Discharge (Tons/Day)	Flow (CFS)	Total Suspended Solids (mg/ℓ)	Suspended Sediment Discharge (Tons/Day)	Flow (CFS)	Total Suspended Solids (mg/ℓ)	Suspended Sediment Discharge (Tons/Day)
4/12/76	23.9	12.7	0.82	–	–	–	–	–	–
5/17/76	61.7	4.7	0.78	–	–	–	–	–	–
5/26/76	43.2	5.8	0.67	–	–	–	–	–	–
6/29/76	34.2	6.7	0.62	–	–	–	–	–	–
8/10/76	22.4	8.7	0.53	–	–	–	–	–	–
9/21/76	25.2	4.4	0.30	–	–	–	–	–	–
3/1/77	36.9	1.2	0.12	–	–	–	–	–	–
4/13/77	17.2	2.6	0.12	4.76	10.5	0.13	22.5	85.0	5.16
5/23/77	27.1	8.9	0.65	3.82	5.1	0.05	7.2	38.5	0.75
7/12/77	17.6	3.2	0.15	1.93	2.7	0.14	5.8	7.3	0.11
8/17/77	20.0	4.8	0.26	–	–	–	–	–	–
9/27/77	31.3	3.4	0.28	–	–	–	–	–	–
11/15/77	22.4	5.8	0.35	4.6	4.9	0.06	6.8	8.0	0.15
3/14/78	35.2	2.6	0.28	5.7	6.1	0.09	15.6	11.0	0.46
4/25/78	31.1	2.2	0.18	5.2	2.1	0.03	13.0	8.6	0.30

– = No data obtained.

NOTE: Station 3.5 was in one of the channels of the braided stream.

VEGP - OLSER

TABLE 13

ESTIMATED BEDLOAD DISCHARGE AT STATION 3.0 USING THE SCHOKLITSCH FORMULA.

Date	Stream Width (Ft.)	Q_0	D	Q_{01}	G_1	Estimated Bedload Discharge Tons/Day
4/12/76	28	23.9	0.575	0.24	0.14	170
5/17/76	32	61.7	0.464	0.18	0.37	510
5/26/76	31	43.2	0.473	0.18	0.26	350
6/29/76	29.5	34.2	0.503	0.20	0.20	260
8/10/76	30	22.4	0.469	0.18	0.13	175
9/21/76	30	25.2	0.544	0.22	0.15	195
4/13/77	37	17.2	0.593	0.26	0.10	165
5/23/77	33	27.1	0.462	0.18	0.16	230
7/12/77	31	17.6	0.411	0.15	0.11	140
9/27/77	32	31.3	0.554	0.23	0.19	260
11/15/77	32	22.4	0.563	0.23	0.13	185
3/14/78	32	35.2	0.394	0.14	0.21	290
4/25/78	31	31.1	0.384	0.13	0.19	250

Slope = 0.00114

NOTE: Because of the empirical nature of the formulas, the bedload discharges are not exact values, but approximations.

Symbols: Q_0 = Stream discharge ft^3/sec

D = Particle diameter (ft)

Q_{01} = Critical flow

G = Bedload

TABLE 14

ESTIMATED BEDLOAD DISCHARGE AT STATIONS 3.5 and 6.0 USING THE SCHOKLITSCH FORMULA.

Station 3.5

Date	Stream Width (Ft)	Q_0	D	Q_{01}	G	Bedload Discharge Tons/Day
4/13/77	13	4.8	0.448	0.17	0.03	15
5/23/77	12	3.8	0.470	0.19	0.02	10
7/12/77	12	1.9	0.387	0.14	0.01	5
11/15/77	12	4.6	0.392	0.14	0.03	13
3/14/78	12	5.7	0.474	0.19	0.03	16
4/25/78	12	5.2	0.438	0.17	0.03	15

Slope at Station 3.5 = 0.0011

Station 6.0

Date	Stream Width (Ft)	Q_0	D	Q_{01}	G	Bedload Discharge Tons/Day
4/13/77	24	22.5	0.533	0.06	0.07	780
5/23/77	21	7.2	0.561	0.06	0.24	220
7/12/77	18	5.8	0.491	0.05	0.19	150
11/15/77	20	6.8	0.636	0.07	0.23	200
3/14/78	20	15.6	0.586	0.07	0.52	450
4/25/78	20	13.0	0.643	0.08	0.44	420

Slope at Station 6.0 = 0.0036

NOTE: Because of the empirical nature of the formulas, the bedload discharges are not exact values, but are approximations.

Symbols: Q_0 = Stream discharge ft^3/sec

D = Particle diameter (ft)

Q_{01} = Critical flow

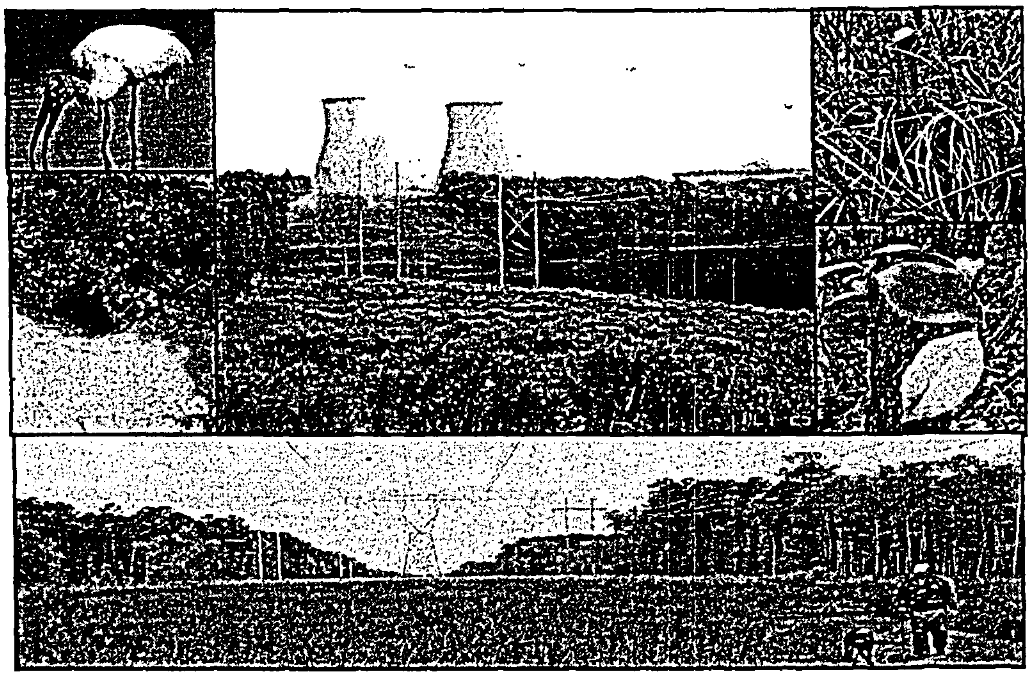
G = Bedload

Section 2.4.1 (TRC 2006)

V-33

Threatened and Endangered Species Survey Final Report

Vogtle Electric Generating Plant and Associated Transmission Corridors



for

Tetra Tech NUS, Inc.
900 Trail Ridge Road
Aiken, South Carolina 29803

January 16, 2006

THIRDROCK CONSULTANTS

www.thirdrockconsultants.com

Environmental Analysis & Restoration

(USFWS 1998)

For Immediate Release
August 19, 1998

Contact: Tom MacKenzie
404/679-7291
Diana Hawkins
404/679-7293

RARE FISH, ONCE THOUGHT TO BE EXTINCT, NOW STAGING A COMEBACK

V-481

For 122 years the fish was believed to be extinct. Then in 1991, biologists from the Georgia Department of Natural Resources discovered some robust redhorse in the Oconee River near Toomsboro,Georgia.Scientists estimated that this population remnant, surviving along a 70-mile stretch of river,numbered as few as 2,000. Today, some 7 years later, more than 27,900 artificially-reared fish have been introduced into Georgia Atlantic slope rivers.

[x] r98-76a.jpg (4011 bytes)

As its name implies, the robust redhorse is a sizable fish, that when fully-grown measures up to 30 inches in length and weighs as much as 17 pounds. It was first described in 1870 by a renowned naturalist of the time, Edward Drinker Cope. The fish is believed to have once existed in large numbers in the then-pristine rivers of Georgia and the Carolinas. Remains of the species found at archeological sites in the Southeast clearly indicate that it was once an important food source for Native Americans and perhaps early settlers as well.

After its rediscovery seven years ago, biologists studied the Oconee River population between Milledgeville and Dublin, Georgia, and found it to consist almost entirely of older adults. The fish, which has a longer life span than most freshwater species, can live for as long as 26 years. The advanced average age of these survivors, however, raised an immediate red flag to fisheries experts, because it clearly indicated that the fish's reproductive rates were poor.

Once it became evident that the future of the new-found robust redhorse was nothing short of perilous, the Robust Redhorse Conservation Committee was established in 1995. Signatories to the Memorandum of Understanding, a document outlining the mission of the Committee, are the Georgia Department of Natural Resources, the U.S. Fish and Wildlife Service, the South Carolina Department of Natural Resources, the North Carolina Wildlife Resources Commission, the U.S. Geological Survey-Biological Resources Division, U.S. Forest Service, U.S. Army Corps of Engineers, Georgia Power Company, Carolina Power and Light, Duke Power, the University of Georgia and the Georgia Wildlife Federation. The mission of the Committee is to analyze factors leading to the decline of the fish, to attempt to re-establish the species to a sustainable level within its former range and to take actions that will recover the species to the point that it will not have to be placed on the federal list of endangered and threatened species. The overall coordination of the recovery effort is under the general direction of the Georgia DNR.

To aid in its recovery, fisheries biologists in the Spring of 1992, began collecting brood fish from the river and transporting them to the Service's Warm Springs National Fish Hatchery in Warm Springs, Georgia. Later, a decision was made to transport fertilized eggs from the Oconee River to the Warm Springs hatchery rather than shipping the brood fish. The process of collecting fertilized eggs was no mean feat. It involved the research team developing just the right hormone treatment to induce the females to ovulate and release ripe eggs while obtaining sperm from the male fish to fertilize them. Although initial efforts were unsuccessful, later studies conducted in cooperation with the University of Georgia and funded by Georgia Power Company have led to the production, to date, of 409,000 fry.

According to the Service's Southeast Regional Director, Sam Hamilton, another challenge facing biologists was to find the exact conditions necessary to allow the embryos to develop into fingerlings -- young fish approximately 3-

5 inches long. Over a two-year period, beginning in March 1995, some 25,000 fry , stocked in state hatcheries in Georgia and South Carolina. Here they thrived and were eventually released as 8-10-inch fingerlings into Georgia's Broad River -- a tributary of the Savannah River. Approximately 1,500 others were introduced into the nearby Ogeechee River. An additional number were retained in ponds at the Warm Springs National Fish Hatchery to produce larger juveniles and adults for further study and intensive culture testing while some 4,500 other fish are being held at the Piedmont National Wildlife Refuge near Round Oak, Georgia, to serve as a backup robust redhorse community just in case some catastrophic event decimates the surviving Oconee River population.

Hamilton said he is heartened by the recent outstanding fingerling survival rates in hatchery ponds and noted that these rates are the highest achieved in the 6 years that the recovery effort has been in place. "This success represents a significant advance in recovery efforts for the species," he said. He noted, however, that the fish's ultimate fate rests upon much larger issues.

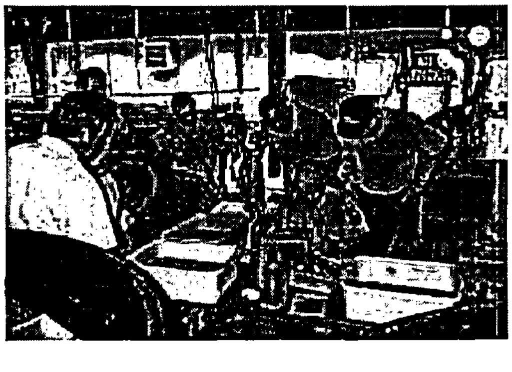
The major causes of the decline and extinction of fish and mussel species in the Southeastern United States, Hamilton said, are the sedimentation of rivers and streams, the damming of waterways that isolate populations and block migration channels, and the introduction of exotic species that prey on native species or, like the zebra mussel, inundate their habitats.

During the past 100 years, human settlement in the Southeast has resulted in extensive erosion and sedimentation of rivers and streams caused by deforestation, commercial development and row crop agricultural practices. The damming of waterways and the extensive muddying of once-clear and pristine waters may also have seriously harmed species like the robust redhorse, that migrates to shallow river areas, covered with clean gravel spawning sites to protect eggs and developing larvae.

The fertilized eggs incubate and hatch in the small spaces between the tiny pieces of gravel. The newly-hatched larvae are unable to swim and in the 8-11 days it takes for their delicate yolk sacks to be absorbed, they need the shelter offered by the gravel. They cannot survive if smothered by layers of silt.

Since the late 1800s, dams have been built on almost all rivers within the historic range of the robust redhorse. These dams have blocked migration channels and impoundments have inundated spawning areas. An additional threat to this fish was the introduction, in the 1960s and 1970s, of the flathead catfish.. This voracious predator is considered responsible for the decline of a number of native fish species.

In spite of the Committee's successes, to date, to recover the robust redhorse, Hamilton says the Service and its partners will still have to play a waiting game. "Only time will tell if the fish, once recovered, can continue to maintain a sustainable population level," he said.



River-bound fingerlings are fitted with tags that enable scientists to follow a fish's progress. "The robust redhorse reaches sexual maturity in about 7 years and it's going to take us at least that long to really tell if the reintroduction works," Hamilton said.

The U.S. Fish and Wildlife Service is the principal Federal agency responsible for conserving, protecting, and enhancing fish and wildlife and their habitats for the continuing benefit of the American people. The Service's nearly 93 million acres include 514 national wildlife refuges, 78 ecological services field stations, 66 national fish hatcheries, 50 wildlife coordination areas, and 38 wetland management districts with waterfowl production areas.

The agency enforces Federal wildlife laws, manages migratory bird populations, restores nationally significant fisheries, conserves and restores wildlife habitat such as wetlands, administers the Endangered Species Act, and helps foreign governments with their conservation efforts. It also oversees the Federal Aid program that distributes Federal excise taxes on fishing and hunting equipment to state wildlife agencies. This program is a cornerstone of the Nation's wildlife management efforts, funding fish and wildlife restoration, boating access, hunter education, shooting ranges, and related projects across America.

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Release #: R98-076

1998 News Releases

Go to the U.S. Fish and Wildlife Service Southeast Region Home Page

 (USFWS 2004) Section 2.4.1

U.S. Fish & Wildlife Service

Georgia Ecological Services
Athens, Brunswick & Columbus REGION 4

Home >News & Information >

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Contents

Endangered Species in Georgia

Georgia provides habitat for 63 species for plants and animals protected under the federal Endangered Species Act. The state of Georgia has its own lists of plants and animals that are considered to be threatened or endangered. These species including the ones listed below can also be protected under state law.

Endangered Species of Georgia

Endangered Species of Georgia is a list of the plants, invertebrates, fish, reptiles, amphibians, birds and mammals protected under the Endangered Species Act. (This is a pdf file.)

County Index

County by County Index -- Interactive list of **federally listed** endangered species in Georgia.

Descriptions

Listings of endangered species including their status, range and habitat.

Plants
Invertebrates - spiders, insects, mussels, snails,
Fish
Reptiles and Amphibians
Birds
Mammals

The Endangered Species Program

The Endangered Species Program page at the national USFWS website puts you in contact with service-wide information, links, and news regarding threatened and endangered species.

The Endangered Species Act and What We Do

The Endangered Species Act and What We Do website provides additional information about the Endangered Species Act, the text of the Endangered Species Act itself, and information concerning the role of the U.S. Fish and Wildlife Service.

National Database Access

The Environmental Conservation Online System or ECOS is a select set of national U.S. Fish & Wildlife Service databases and applications. ECOS provides s a central access point for data integration, queries, reports, summaries, data editing, spatial analysis tools, map generation and data export.

Definitions

Glossary of definitions relating to the Endangered Species Act.

State of Georgia Definitions

Endangered: A species which is in danger of extinction throughout all or part of its range.

Threatened: A species which is likely to become an endangered species in the foreseeable future throughout all or part of its range.

Rare: A species which may not be endangered or threatened but which should be protected because of its rarity.

Unusual: A species which has special or unique features that entitle it to special consideration to ensure its continued survival.

Questions & Answers

What if an Endangered Species Lives on your Property?...

What is the Partners For Fish And Wildlife program?

How do I find out about grants that may help endangered species?

Who do I contact for more information?

Listed Species in Burke County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Bird				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Wood stork *Mycteria americana*	E	E	Primarily feed in fresh and brackish wetlands and nest in cypress or other wooded swamps	Decline due primarily to loss of suitable feeding habitat, particularly in south Florida. Other factors include loss of nesting habitat, prolonged drought/flooding, raccoon predation on nests, and human disturbance of rookeries.
Reptile				
Gopher tortoise *Gopherus polyphemus*	No Federal Status	T	Well-drained, sandy soils in forest and grassy areas; associated with pine overstory, open understory with grass and forb groundcover, and sunny areas for nesting	Habitat loss and conversion to closed canopy forests. Other threats include mortality on highways and the collection of tortoises for pets.
Amphibian				
Flatwoods salamander *Ambystoma cingulatum*	T	T	Adults and subadults are fossorial; found in open mesic pine/wiregrass flatwoods dominated by longleaf or slash pine and maintained by frequent fire. During breeding period, which coincides with heavy rains from Oct.-Dec., move to isolated, shallow, small, depressions (forested with emergent vegetation) that dry completely on a cyclic basis. Last breeding record for Burke County was in the 1940's.	Habitat destruction as a result of agricultural an silvicultural practices (e.g., clearclutting, mechanical site preparation), fire suppresion and residential and commercial development.
Invertebrate				
Atlantic pigtoe mussel *Fusconaia masoni*	No Federal Status	E	Found in unpolluted, fast-flowing water in coarse sand/gravel substrate.	
Fish				
Shortnose sturgeon[1] *Acipenser brevirostrum*	E	E	Atlantic seaboard rivers	Construction of dams and pollution, habitat alterations from discharges, dredging or disposal of material into rivers, and related development activities.
Plant				
Canby's dropwort *Oxypolis canbyi*	E	E	Peaty muck of shallow cypress ponds, wet pine savannahs, and adjacent sloughs and drainage ditches	Loss or alteration of wetland habitats
Georgia plume *Elliottia racemosa*	No Federal Status	T	Sand ridges, dry oak ridges, evergreen hammocks, and sandstone outcrops in a variety of sandy soil conditions ranging from moist to very dry	
Indian olive	No	T	Dry open upland forests of mixed hardwood	

Nestronia umbellula	Federal Status		and pine
Ocmulgee skullcap *Scutellaria ocmulgee*	No Federal Status	T	Forested terraces, hardwood slopes and riverbanks of tributaries to the Ocmulgee, Oconee, and Savannah Rivers
Rosemary *Ceratiola ericoides*	No Federal Status	T	Driest, openly vegetated, scrub oak sandhills and river dunes with deep white sands of the Kershaw soil series
Sweet pitcher-plant *Sarracenia rubra*	No Federal Status	E	Acid soils of open bogs, sandhill seeps, Atlantic white-cedar swamps, wet savannahs, low areas in pine flatwoods, and along sloughs and ditches

[1]This species is the responsibility of the National Marine Fisheries Service.

Listed Species in Jefferson County (updated May 2004)

Species	Federal Status	State Status	Habitat	Threats
Bird				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia. An active bald eagle nest was located in Jefferson County in 1999 and 2002.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Wood stork *Mycteria americana*	E	E	Primarily feed in fresh and brackish wetlands and nest in cypress or other wooded swamps	Decline due primarily to loss of suitable feeding habitat, particularly in south Florida. Other factors include loss of nesting habitat, prolonged drought/flooding, raccoon predation on nests, and human disturbance of rookeries.
Reptile				
Gopher tortoise *Gopherus polyphemus*	No Federal Status	T	Well-drained, sandy soils in forest and grassy areas; associated with pine overstory, open understory with grass and forb groundcover, and sunny areas for nesting	Habitat loss and conversion to closed canopy forests. Other threats include mortality on highways and the collection of tortoises for pets.
Amphibian				
Flatwoods salamander *Ambystoma cingulatum*	T	T	Adults and subadults are fossorial; found in open mesic pine/wiregrass flatwoods dominated by longleaf or slash pine and maintained by frequent fire. During breeding period, which coincides with heavy rains from Oct.-Dec., move to isolated, shallow, small, depressions (forested with emergent vegetation) that dry completely on a cyclic basis. Found in Jefferson County October 1997	Habitat destruction as a result of agricultural an silvicultural practices (e.g., clearclutting, mechanical site preparation), fire suppresion and residential and commercial development.
Invertebrate				
Atlantic pigtoe mussel *Fusconaia masoni*	No Federal Status	E	Found in unpolluted, fast-flowing water in coarse sand/gravel substrate.	
Plant				
Indian olive *Nestronia umbellula*	No Federal Status	T	Dry open upland forests of mixed hardwood and pine	
Sweet pitcher-plant *Sarracenia rubra*	No Federal Status	E	Acid soils of open bogs, sandhill seeps, Atlantic white-cedar swamps, wet savannahs, low areas in pine flatwoods, and along sloughs and ditches	

Listed Species in McDufffie County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Bird				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia. An active eagle nest was located in McDuffie County in 1998 and 2002.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.

Listed Species in Warren County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Bird				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Invertebrate				
Atlantic pigtoe mussel *Fusconaia masoni*	No Federal Status	E	Found in unpolluted, fast-flowing water in coarse sand/gravel substrate.	
Plant				
Granite rock stonecrop *Sedum pusillum*	No Federal Status	T	Granite outcrops among mosses in partial shade under red cedar trees	

Listed Species in Richmond County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Bird				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Wood stork *Mycteria americana*	E	E	Primarily feed in fresh and brackish wetlands and nest in cypress or other wooded swamps	Decline due primarily to loss of suitable feeding habitat, particularly in south Florida. Other factors include loss of nesting habitat, prolonged drought/flooding, raccoon predation on nests, and human disturbance of rookeries.
Reptile				
Gopher tortoise *Gopherus polyphemus*	No Federal Status	T	Well-drained, sandy soils in forest and grassy areas; associated with pine overstory, open understory with grass and forb groundcover, and sunny areas for nesting	Habitat loss and conversion to closed canopy forests. Other threats include mortality on highways and the collection of tortoises for pets.
Invertebrate				
Atlantic pigtoe mussel *Fusconaia masoni*	No Federal Status	E		
Plant				
Dwarf witch-alder *Fothergilla gardenii*	No Federal Status	T	Low, flat, swampy areas, especially shrub-dominated margins of upland swamps (pocosins), Carolina bays, pitcherplant bogs, wet savannahs, and Atlantic white-cedar swamps	
Georgia plume *Elliottia racemosa*	No Federal Status	T	Sand ridges, dry oak ridges, evergreen hammocks, and sandstone outcrops in a variety of sandy soil conditions ranging from moist to very dry	
Indian olive *Nestronia umbellula*	No Federal Status	T	Dry open upland forests of mixed hardwood and pine	
Ocmulgee skullcap *Scutellaria ocmulgee*	No Federal Status	T	Forested terraces, hardwood slopes and riverbanks of tributaries to the Ocmulgee, Oconee, and Savannah Rivers	
Parrot pitcher-plant *Sarracenia psittacina*	No Federal Status	T	Acid soils of open bogs, wet savannahs, and low areas in pine flatwoods; a reported population in Richmond County may have been misidentified	
Pickering's morning-glory *Stylisma*	No Federal Status	T	Coarse white sands on sandhills near the Fall Line and on a few ancient dunes along the Flint and Ohoopee Rivers	

pickeringii			
Rosemary *Ceratiola ericoides*	No Federal Status	T	Driest, openly vegetated, scrub oak sandhills and river dunes with deep white sands of the Kershaw soil series
Shoals spider-lily *Hymenocallis coronaria*	No Federal Status	E	Major streams and rivers in rocky shoals and in cracks of exposed bedrock; plants can be completely submerged during flooding
Sweet pitcher-plant *Sarracenia rubra*	No Federal Status	E	Acid soils of open bogs, sandhill seeps, Atlantic white-cedar swamps, wet savannahs, low areas in pine flatwoods, and along sloughs and ditches

[1]This species is the responsibility of the National Marine Fisheries Service.

Listed Species in Monroe County (updated May 2004)				
Species	Federal Status	State Status	Habitat	Threats
Bird				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia. Active eagle nests were located in Monroe County 1989-1999. No active nests in 2000-2001	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Fish				
Altamaha shiner *Cyprinella xaenura*	No Federal Status	E	Upper Altamaha River drainage of north Georgia; Inhabit small tributaries and rivers. Most often found in small pools with rocky to sandy substrates	Habitat loss due to dam and reservoir construction, habitat degradation, and poor water quality

Listed Species in Jones County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Bird				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Fish				
Altamaha shiner *Cyprinella xaenura*	No Federal Status	E	Upper Altamaha River drainage of north Georgia; Inhabit small tributaries and rivers. Most often found in small pools with rocky to sandy substrates	Habitat loss due to dam and reservoir construction, habitat degradation, and poor water quality
Plant				
Ocmulgee skullcap *Scutellaria ocmulgee*	No Federal Status	T	Forested terraces, hardwood slopes and riverbanks of tributaries to the Ocmulgee, Oconee, and Savannah Rivers	
Relict trillium *Trillium reliquum*	E	E	Hardwood forests; in the Piedmont, found in either in rich ravines or adjacent alluvial terraces with other spring-flowering herbs	Logging, road construction, agricultural conversion, mining, residential/industrial development, and encroachment by Japanese honeysuckle and kudzu

Listed Species in Baldwin County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Birds				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia. Active eagle nests were located in Balwin county in 2000-2002	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Fish				
Robust redhorse *Moxostoma robustum*	No Federal Status	E	Medium to large rivers with shallow to deep flowing moderately swift water. .	
Plants				
American chaffseed *Schwalbea americana*	E	E	Fire-maintained wet savannahs in the Coastal Plain (with grass pinks, colic root, huckleberry and gallberry); grassy openings and swales of relict longleaf pine woods in the Piedmont	Fire suppression, habitat conversion, and incompatible agriculture and forestry practices

Listed Species in Putnam County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Bird				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Fish				
Altamaha shiner *Cyprinella xaenura*	No Federal Status	E	Upper Altamaha River drainage of north Georgia; Inhabit small tributaries and rivers. Most often found in small pools with rocky to sandy substrates	Habitat loss due to dam and reservoir construction, habitat degradation, and poor water quality
Robust redhorse *Moxostoma robustum*	No Federal Status	E	Medium to large rivers with shallow to deep flowing moderately swift water.	
Plant				
Mat-forming quillwort *Isoetes tegetiformans*	E	E	Shallow pools on granite outcrops, where water collects after a rain. Pools are less than 1 foot deep and rock rimmed.	Quarrying that destroys granite outcrops is the major threat. Other threats include vehicle traffic, littering, fire building, vandalism, and cattle eutrophication/trampling on outcrops.
Pool Sprite, Snorkelwort *Amphianthus pusillus*	T	T	Shallow pools on granite outcrops, where water collects after a rain. Pools are less than 1 foot deep and rock rimmed	

Listed Species in Hancock County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Bird				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia. Active eagle nests were located in Hancock County in 1988-1999 and 2000-2002	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Fish				
Robust redhorse *Moxostoma robustum*	No Federal Status	E	Medium to large rivers with shallow to deep flowing moderately swift water	
Plant				
Mat-forming quillwort *Isoetes tegetiformans*	E	E	Shallow pools on granite outcrops, where water collects after a rain. Pools are less than 1 foot deep and rock rimmed.	Quarrying that destroys granite outcrops is the major threat. Other threats include vehicle traffic, littering, fire building, vandalism, and cattle eutrophication/trampling on outcrops.
Pool Sprite, Snorkelwort *Amphianthus pusillus*	T	T	Shallow pools on granite outcrops, where water collects after a rain. Pools are less than 1 foot deep and rock rimmed	

Listed Species in Washington County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Bird				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Fish				
Robust redhorse *Moxostoma robustum*	No Federal Status	E	Medium to large rivers with shallow to deep flowing moderately swift water.	
Plant				
Bay star-vine *Schisandra glabra*	No Federal Status	T	Twining on subcanopy and understory trees/shrubs in rich alluvial woods	
Harper dodder *Cuscuta harperi*	No Federal Status	T	Parasite usually found on rayless-goldenrod (*Chondrophora virgata*); rarely parasitic on other herbs found on granite or sandstone outcrops	

Species	Federal Status	State Status	Habitat	Threats
Listed Species in Jefferson County (updated May 2004)				
Bird				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia. An active bald eagle nest was located in Jefferson County in 1999 and 2002.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Wood stork *Mycteria americana*	E	E	Primarily feed in fresh and brackish wetlands and nest in cypress or other wooded swamps	Decline due primarily to loss of suitable feeding habitat, particularly in south Florida. Other factors include loss of nesting habitat, prolonged drought/flooding, raccoon predation on nests, and human disturbance of rookeries.
Reptile				
Gopher tortoise *Gopherus polyphemus*	No Federal Status	T	Well-drained, sandy soils in forest and grassy areas; associated with pine overstory, open understory with grass and forb groundcover, and sunny areas for nesting	Habitat loss and conversion to closed canopy forests. Other threats include mortality on highways and the collection of tortoises for pets.
Amphibian				
Flatwoods salamander *Ambystoma cingulatum*	T	T	Adults and subadults are fossorial; found in open mesic pine/wiregrass flatwoods dominated by longleaf or slash pine and maintained by frequent fire. During breeding period, which coincides with heavy rains from Oct.-Dec., move to isolated, shallow, small, depressions (forested with emergent vegetation) that dry completely on a cyclic basis. Found in Jefferson County October 1997	Habitat destruction as a result of agricultural an silvicultural practices (e.g., clearclutting, mechanical site preparation), fire suppresion and residential and commercial development.
Invertebrate				
Atlantic pigtoe mussel *Fusconaia masoni*	No Federal Status	E	Found in unpolluted, fast-flowing water in coarse sand/gravel substrate.	
Plant				
Indian olive *Nestronia umbellula*	No Federal Status	T	Dry open upland forests of mixed hardwood and pine	
Sweet pitcher-plant *Sarracenia rubra*	No Federal Status	E	Acid soils of open bogs, sandhill seeps, Atlantic white-cedar swamps, wet savannahs, low areas in pine flatwoods, and along sloughs and ditches	

Listed Species in Screven County (updated May 2004)

Species	Federal Status	State Status	Habitat	Threats
Bird				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Wood stork *Mycteria americana*	E	E	Primarily feed in fresh and brackish wetlands and nest in cypress or other wooded swamps. Active rookeries were located in Screven County in 1995-1999. Rookeries were not successful in 2001	Decline due primarily to loss of suitable feeding habitat, particularly in south Florida. Other factors include loss of nesting habitat, prolonged drought/flooding, raccoon predation on nests, and human disturbance of rookeries.
Reptile				
Eastern indigo snake *Drymarchon corais couperi*	T	T	During winter, den in xeric sandridge habitat preferred by gopher tortoises; during warm months, forage in creek bottoms, upland forests, and agricultural fields	Habitat loss due to uses such as farming, construction, forestry, and pasture and to overcollecting for the pet trade
Gopher tortoise *Gopherus :olyphemus*	No Federal Status	T	Well-drained, sandy soils in forest and grassy areas; associated with pine overstory, open understory with grass and forb groundcover, and sunny areas for nesting	Habitat loss and conversion to closed canopy forests. Other threats include mortality on highways and the collection of tortoises for pets.
Amphibian				
Flatwoods salamander *Ambystoma cingulatum*	T	T	Adults and subadults are fossorial; found in open mesic pine/wiregrass flatwoods dominated by longleaf or slash pine and maintained by frequent fire. During breeding period, which coincides with heavy rains from Oct.-Dec., move to isolated, shallow, small, depressions (forested with emergent vegetation) that dry completely on a cyclic basis. Last breeding record for Screven County was in the 1940's.	Habitat destruction as a result of agricultural an silvicultural practices (e.g., clearclutting, mechanical site preparation), fire suppresion and residential and commercial development.
Invertebrate				
Atlantic pigtoe mussel *Fusconaia masoni*	No Federal Status	E	Found in unpolluted, fast-flowing water in coarse sand/gravel substrate.	
Fish				
lobust ɜdhorse *'oxostoma bustum*	No Federal Status	T	Medium to large rivers with shallow to deep flowing moderately swift water.	
ıortnose ırgeon[1] *'penser vi 'rum*	E	E	Atlantic seaboard rivers	Construction of dams and pollution, habitat alterations from discharges, dredging or disposal of material into rivers, and related development activities.

Canby's dropwort *Oxypolis canbyi*	E	E	Peaty muck of shallow cypress ponds, wet pine savannahs, and adjacent sloughs and drainage ditches	Loss or alteration of wetland habitats
Pondberry *Lindera melissifolia*	E	E	Shallow depression ponds of sandhills, margins of cypress ponds, and in seasonally wet low areas among bottomland hardwoods	
Pondspice *Litsea aestivalis*	No Federal Status	T	Margins of swamps, cypress ponds, and sandhill depression ponds and in hardwood swamps	

[1]This species is the responsibility of the National Marine Fisheries Service.

Listed Species In Effingham County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Bird				
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Wood stork *Mycteria americana*	E	E	Primarily feed in fresh and brackish wetlands and nest in cypress or other wooded swamps	Decline due primarily to loss of suitable feeding habitat, particularly in south Florida. Other factors include loss of nesting habitat, prolonged drought/flooding, raccoon predation on nests, and human disturbance of rookeries.
Reptile				
Eastern indigo snake *Drymarchon corais couperi*	T	T	During winter, den in xeric sandridge habitat preferred by gopher tortoises; during warm months, forage in creek bottoms, upland forests, and agricultural fields	Habitat loss due to uses such as farming, construction, forestry, and pasture and to overcollecting for the pet trade
Gopher tortoise *Gopherus polyphemus*	No Federal Status	T	Well-drained, sandy soils in forest and grassy areas; associated with pine overstory, open understory with grass and forb groundcover, and sunny areas for nesting	Habitat loss and conversion to closed canopy forests. Other threats include mortality on highways and the collection of tortoises for pets.
Amphibian				
Flatwoods salamander *Ambystoma cingulatum*	T	T	Adults and subadults are fossorial; found in open mesic pine/wiregrass flatwoods dominated by longleaf or slash pine and maintained by frequent fire. During breeding period, which coincides with heavy rains from Oct.-Dec., move to isolated, shallow, small, depressions (forested with emergent vegetation) that dry completely on a cyclic basis. Last breeding record for Effingham County was in 1962-1963.	
Fish				
Shortnose sturgeon[1] *Acipenser brevirostrum*	E	E	Atlantic seaboard rivers	
Plant				
Dwarf witch-alder *Fothergilla gardenii*	No Federal Status	T	Low, flat, swampy areas, especially shrub-dominated margins of upland swamps (pocosins), Carolina bays, pitcherplant bogs, wet savannahs, and Atlantic white-cedar swamps	
Pondberry *Lindera melissifolia*	E	E	Shallow depression ponds of sandhills, margins of cypress ponds, and in seasonally wet low areas among bottomland hardwoods	Drainage ditching and subsequent conversion of habitat to other uses; domestic hogs, cattle grazing, and timber harvesting; and apparent lack of seedling production
Pondspice	No	T	Margins of swamps, cypress ponds, and	

Litsea aestivalis	Federal Status	sandhill depression ponds and in hardwood swamps	

…is species is the responsibility of the National Marine Fisheries Service.

Listed Species in Chatham County
(updated May 2004)

Species	Federal Status	State Status	Habitat	Threats
Mammal				
Humpback whale *Megaptera novaeangliae*	E	E	Coastal waters during migration	Entanglement in commercial fishing gear and collisions/disturbance associated with boats and barges
Right whale *Eubalaena glacialis*	E	E	Mate and calve in shallow coastal waters	Initial decreases probably due to overharvesting. Slow population growth after exploitation halted may be due to collisions/disturbance associated with boats and barges, inbreeding, inherently low reproductive rates, or a reduction in population below a critical size for successful reproduction.
West Indian manatee *Trichechus manatus*	E	E	Coastal waters, estuaries, and warm water outfalls	Initial decreases probably due to overharvesting for meat, oil and leather. Current mortality due to collisions with boats and barges and from canal lock operations. Declines also related to coastal development and loss of suitable habitat, particularly destruction of seagrass beds.
Bird				
Bachman's warbler *Vermivora bachmanii*	E	E	Probably extinct; last seen in Georgia in 1976	
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia. Active eagle nests were located in Chatham County 1988-1999 and 2000-2002.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Gull-billed tern *Sterna nilotica*	No Federal Status	T	Nests in colonies on sandy sites; forages over salt marsh, dunes and other grassy areas for insects, spiders, and other invertebrates	
Piping plover *Charadrius melodus*	T	T	Winter on Georgia's coast; prefer areas with expansive sand or mudflats (foraging) in close proximity to a sand beach (roosting)	Habitat alteration and destruction and human disturbance in nesting colonies. Recreational and commercial development have contributed greatly to loss of breeding habitat.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Wood stork *Mycteria americana*	E	E	Primarily feed in fresh and brackish wetlands and nest in cypress or other wooded swamps. Active rookeries were found in Chatham county in 2001 & 2002.	Decline due primarily to loss of suitable feeding habitat, particularly in south Florida. Other factors include loss of nesting habitat, prolonged drought/flooding, raccoon predation on nests, and human disturbance of rookeries.
Reptile				
Eastern indigo snake *Drymarchon corais couperi*	T	T	During winter, den in xeric sandridge habitat preferred by gopher tortoises; during warm months, forage in creek bottoms, upland forests, and agricultural fields	Habitat loss due to uses such as farming, construction, forestry, and pasture and to overcollecting for the pet trade
Gopher	No	T	Well-drained, sandy soils in forest and	Habitat loss and conversion to closed

tortoise *Gopherus polyphemus*	Federal Status		grassy areas; associated with pine overstory, open understory with grass and forb groundcover, and sunny areas for nesting	canopy forests. Other threats include mortality on highways and the collection of tortoises for pets.
Green sea turtle *Chelonia mydas*	T	T	Rarely nests in Georgia; migrates through Georgia's coastal waters	Exploitation for food, high levels of predation, loss of nesting habitat due to human encroachment, hatchling disorientation due to artificial lights on beaches, and drownings when trapped in fishing and shrimping nets
Hawksbill sea turtle *Eretmochelys imbricata*	E	E	Migrates through Georgia's coastal waters	Primary causes of population decline are development and modification of nesting beaches and exploitation for the shell. Secondary causes include egg consumption, use of the skin for leather, and heavy predation of eggs and hatchlings.
Kemp's ridley sea turtle *Lepidochelys kempi*	E	E	Migrates through Georgia's coastal waters	Overharvesting of eggs and adults for food and skins and drowning when caught in shrimp nets
Leatherback sea turtle *Dermochelys coriacea*	E	E	Rarely nests in Georgia; migrates through Georgia's coastal waters	Human exploitation, beach development, high predation on hatchlings, and drowning when caught in nets of commercial shrimp and fish trawls and longline and driftnet fisheries
Loggerhead sea turtle *Caretta caretta*	T	T	Nests on Georgia's barrier island beaches; forages in warm ocean waters and river mouth channels	Loss of nesting beaches due to human encroachment, high natural predation, drownings when turtles trapped in fishing and shrimping trawls, and marine pollution
Amphibian				
Flatwoods salamander *Ambystoma cingulatum*	T	T	Adults and subadults are fossorial; found in open mesic pine/wiregrass flatwoods dominated by longleaf or slash pine and maintained by frequent fire. During breeding period, which coincides with heavy rains from Oct.-Dec., move to isolated, shallow, small, depressions (forested with emergent vegetation) that dry completely on a cyclic basis. Historic and new breeding sites active in Bryan County since 1990.	
Fish				
Shortnose sturgeon[1] *Acipenser brevirostrum*	E	E	Atlantic seaboard rivers	Construction of dams and pollution, habitat alterations from discharges, dredging or disposal of material into rivers, and related development activities.
Plant				
Climbing buckthorn *Sageretia minutiflora*	No Federal Status	T	Calcareous rocky bluffs, forested shell middens on barrier islands, and evergreen hammocks along streambanks and coastal marshes	
Narrowleaf obedient plant *Physostegia leptophylla*	No Federal Status	T	Wet muck or peat in shallow water of river swamp openings and in the margins of both fresh and brackish (tidal) marshes	
Pondberry *Lindera melissifolia*	E	E	Shallow depression ponds of sandhills, margins of cypress ponds, and in seasonally wet low areas among bottomland hardwoods	Drainage ditching and subsequent conversion of habitat to other uses; domestic hogs, cattle grazing, and timber harvesting; and apparent lack of seedling production

[1]This species is the responsibility of the National Marine Fisheries Service.

Listed Species in Bryan County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Mammal				
Humpback whale *Megaptera novaeangliae*	E	E	Coastal waters during migration	Entanglement in commercial fishing gear and collisions/disturbance associated with boats and barges
Right whale *Eubalaena glacialis*	E	E	Mate and calve in shallow coastal waters	Initial decreases probably due to overharvesting. Slow population growth after exploitation halted may be due to collisions/disturbance associated with boats and barges, inbreeding, inherently low reproductive rates, or a reduction in population below a critical size for successful reproduction.
West Indian manatee *Trichechus manatus*	E	E	Coastal waters, estuaries, and warm water outfalls	Initial decreases probably due to overharvesting for meat, oil and leather. Current mortality due to collisions with boats and barges and from canal lock operations. Declines also related to coastal development and loss of suitable habitat, particularly destruction of seagrass beds.
Bird				
Bachman's warbler *Vermivora bachmanii*	E	E	Probably extinct; last seen in Georgia in 1976	
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia. Active eagle nests were located in Bryan County 1992-1999 and 2000-2002.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Piping plover *Charadrius melodus*	T	T	Winter on Georgia's coast; prefer areas with expansive sand or mudflats (foraging) in close proximity to a sand beach (roosting)	Habitat alteration and destruction and human disturbance in nesting colonies. Recreational and commercial development have contributed greatly to loss of breeding habitat.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Wood stork *Mycteria americana*	E	E	Primarily feed in fresh and brackish wetlands and nest in cypress or other wooded swamps	Decline due primarily to loss of suitable feeding habitat, particularly in south Florida. Other factors include loss of nesting habitat, prolonged drought/flooding, raccoon predation on nests, and human disturbance of rookeries.
Reptile				
Eastern indigo snake *Drymarchon corais couperi*	T	T	During winter, den in xeric sandridge habitat preferred by gopher tortoises; during warm months, forage in creek bottoms, upland forests, and agricultural fields	Habitat loss due to uses such as farming, construction, forestry, and pasture and to overcollecting for the pet trade
Green sea turtle *Chelonia mydas*	T	T	Rarely nests in Georgia; migrates through Georgia's coastal waters	Exploitation for food, high levels of predation, loss of nesting habitat due to human encroachment, hatchling disorientation due to artificial lights on beaches, and drownings when trapped in

				fishing and shrimping nets
Gopher tortoise *Gopherus polyphemus*	No Federal Status	T	Well-drained, sandy soils in forest and grassy areas; associated with pine overstory, open understory with grass and forb groundcover, and sunny areas for nesting	Habitat loss and conversion to closed canopy forests. Other threats include mortality on highways and the collection of tortoises for pets.
Hawksbill sea turtle *Eretmochelys imbricata*	E	E	Migrates through Georgia's coastal waters	Primary causes of population decline are development and modification of nesting beaches and exploitation for the shell. Secondary causes include egg consumption, use of the skin for leather, and heavy predation of eggs and hatchlings.
Kemp's ridley sea turtle *Lepidochelys kempi*	E	E	Migrates through Georgia's coastal waters	Overharvesting of eggs and adults for food and skins and drowning when caught in shrimp nets
Leatherback sea turtle *Dermochelys coriacea*	E	E	Rarely nests in Georgia; migrates through Georgia's coastal waters	Human exploitation, beach development, high predation on hatchlings, and drowning when caught in nets of commercial shrimp and fish trawls and longline and driftnet fisheries
Loggerhead sea turtle *Caretta caretta*	T	T	Nests on Georgia's barrier island beaches; forages in warm ocean waters and river mouth channels	Loss of nesting beaches due to human encroachment, high natural predation, drownings when turtles trapped in fishing and shrimping trawls, and marine pollution
Amphibian				
Flatwoods salamander *Ambystoma cingulatum*	T	T	Adults and subadults are fossorial; found in open mesic pine/wiregrass flatwoods dominated by longleaf or slash pine and maintained by frequent fire. During breeding period, which coincides with heavy rains from Oct.-Dec., move to isolated, shallow, small, depressions (forested with emergent vegetation) that dry completely on a cyclic basis. Historic and new breeding sites active in Bryan County since 1990.	
Fish				
Shortnose sturgeon *Acipenser brevirostrum*	E	E	Atlantic seaboard rivers	Construction of dams and pollution, habitat alterations from discharges, dredging or disposal of material into rivers, and related development activities.
Plant				
Georgia plume *Elliottia racemosa*	No Federal Status	T	Sand ridges, dry oak ridges, evergreen hammocks, and sandstone outcrops in a variety of sandy soil conditions ranging from moist to very dry	
Narrowleaf obedient plant *Physostegia leptophylla*	No Federal Status	T	Wet muck or peat in shallow water of river swamp openings and in the margins of both fresh and brackish (tidal) marshes	
Pondspice *Litsea aestivalis*	No Federal Status	T	Margins of swamps, cypress ponds, and sandhill depression ponds and in hardwood swamps	

[1]This species is the responsibility of the National Marine Fisheries Service.

Listed Species in Liberty County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Mammal				
Humpback whale *Megaptera novaeangliae*	E	E	Coastal waters during migration	Entanglement in commercial fishing gear and collisions/disturbance associated with boats and barges
West Indian manatee *Trichechus manatus*	E	E	Coastal waters, estuaries, and warm water outfalls	Initial decreases probably due to overharvesting for meat, oil and leather. Current mortality due to collisions with boats and barges and from canal lock operations. Declines also related to coastal development and loss of suitable habitat, particularly destruction of seagrass beds.
Bird				
Bachman's warbler *Vermivora bachmanii*	E	E	Probably extinct; last seen in Georgia in 1976	
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia. Active eagle nests were located in Liberty County 1989-1999 and 2000-2002.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Piping plover *Charadrius melodus*	T	T	Winter on Georgia's coast; prefer areas with expansive sand or mudflats (foraging) in close proximity to a sand beach (roosting)	Habitat alteration and destruction and human disturbance in nesting colonies. Recreational and commercial development have contributed greatly to loss of breeding habitat.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Wood stork *Mycteria americana*	E	E	Primarily feed in fresh and brackish wetlands and nest in cypress or other wooded swamps. Active rookeries were located in Liberty County 1992-1996. No active rookeries in 2000	Decline due primarily to loss of suitable feeding habitat, particularly in south Florida. Other factors include loss of nesting habitat, prolonged drought/flooding, raccoon predation on nests, and human disturbance of rookeries.
Reptile				
Eastern indigo snake *Drymarchon corais couperi*	T	T	During winter, den in xeric sandridge habitat preferred by gopher tortoises; during warm months, forage in creek bottoms, upland forests, and agricultural fields	Habitat loss due to uses such as farming, construction, forestry, and pasture and to overcollecting for the pet trade
Gopher tortoise *Gopherus polyphemus*	No Federal Status	T	Well-drained, sandy soils in forest and grassy areas; associated with pine overstory, open understory with grass and forb groundcover, and sunny areas for nesting	Habitat loss and conversion to closed canopy forests. Other threats include mortality on highways and the collection of tortoises for pets.
Green sea turtle *Chelonia mydas*	T	T	Rarely nests in Georgia; migrates through Georgia's coastal waters	Exploitation for food, high levels of predation, loss of nesting habitat due to human encroachment, hatchling disorientation due to artificial lights on beaches, and drownings when trapped in fishing and shrimping nets
Kemp's ridley	E	E	Migrates through Georgia's coastal	Overharvesting of eggs and adults for

sea turtle *Lepidochelys kempi*			waters	food and skins and drowning when caught in shrimp nets
Leatherback sea turtle *Dermochelys coriacea*	E	E	Rarely nests in Georgia; migrates through Georgia's coastal waters	Human exploitation, beach development, high predation on hatchlings, and drowning when caught in nets of commercial shrimp and fish trawls and longline and driftnet fisheries
Loggerhead sea turtle *Caretta caretta*	T	T	Nests on Georgia's barrier island beaches; forages in warm ocean waters and river mouth channels	Loss of nesting beaches due to human encroachment, high natural predation, drownings when turtles trapped in fishing and shrimping trawls, and marine pollution
Amphibian				
Flatwoods salamander *Ambystoma cingulatum*	T	T	Adults and subadults are fossorial; found in open mesic pine/wiregrass flatwoods dominated by longleaf or slash pine and maintained by frequent fire. During breeding period, which coincides with heavy rains from Oct.-Dec., move to isolated, shallow, small, depressions (forested with emergent vegetation) that dry completely on a cyclic basis. Active breeding sites in Bryan County since 1990.	Habitat destruction as a result of agricultural an silvicultural practices (e.g., clearclutting, mechanical site preparation), fire suppresion and residential and commercial development.
Fish				
Shortnose sturgeon[1] *Acipenser brevirostrum*	E	E	Atlantic seaboard rivers	Construction of dams and pollution, habitat alterations from discharges, dredging or disposal of material into rivers, and related development activities.
Plant				
Buckthorn *Sideroxylon thornei*	No Federal Status	E	Oak flatwoods where soil normally is saturated for long periods after floods/heavy rain (i.e., calcareous swamps; woods bordering cypress ponds)	
Narrowleaf obedient plant *Physostegia leptophylla*	No Federal Status	T	Wet muck or peat in shallow water of river swamp openings and in the margins of both fresh and brackish (tidal) marshes	

[1]This species is the responsibility of the National Marine Fisheries Service.

Listed Species in Long County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Bird				
Bachman's warbler *Vermivora bachmanii*	E	E	Probably extinct; last seen in Georgia (Long County) in 1976	
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia. Active eagle nests were located in Long County 1993-1999 and 2000-2002.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and to encroachment of hardwood midstory in older age pine stands due to fire suppression
Wood stork *Mycteria americana*	E	E	Primarily feed in fresh and brackish wetlands and nest in cypress or other wooded swamps. Active rookeries were located in Long County in 1995-1998. Rookeries were not successful in 2001	Decline due primarily to loss of suitable feeding habitat, particularly in south Florida. Other factors include loss of nesting habitat, prolonged drought/flooding, raccoon predation on nests, and human disturbance of rookeries.
Invertebrate				
Altamah spinymussel *Elliptio spinosa*	Candidate Species	E		
Reptile				
Eastern indigo snake *Drymarchon corais couperi*	T	T	During winter, den in xeric sandridge habitat preferred by gopher tortoises; during warm months, forage in creek bottoms, upland forests, and agricultural fields	Habitat loss due to uses such as farming, construction, forestry, and pasture and to overcollecting for the pet trade
Gopher tortoise *Gopherus polyphemus*	No Federal Status	T	Well-drained, sandy soils in forest and grassy areas; associated with pine overstory, open understory with grass and forb groundcover, and sunny areas for nesting	Habitat loss and conversion to closed canopy forests. Other threats include mortality on highways and the collection of tortoises for pets.
Amphibian				
Flatwoods salamander *Ambystoma cingulatum*	T	T	Adults and subadults are fossorial; found in open mesic pine/wiregrass flatwoods dominated by longleaf or slash pine and maintained by frequent fire. During breeding period, which coincides with heavy rains from Oct.-Dec., move to isolated, shallow, small, depressions (forested with emergent vegetation) that dry completely on a cyclic basis. Active breeding sites in Long County since 1979.	Habitat destruction as a result of agricultural an silvicultural practices (e.g., clearclutting, mechanical site preparation), fire suppresion and residential and commercial development.
Fish				
Shortnose sturgeon[1] *Acipenser brevirostrum*	E	E	Altamaha River from the confluence to the coast	Construction of dams and pollution, habitat alterations from discharges, dredging or disposal of material into rivers, and related development activities.
Plant				

Dwarf witch-alder *Fothergilla gardenii*	No Federal Status	T	Low, flat, swampy areas, especially shrub-dominated margins of upland swamps (pocosins), Carolina bays, pitcherplant bogs, wet savannahs, and Atlantic white-cedar swamps
Georgia plume *Elliottia racemosa*	No Federal Status	T	Sand ridges, dry oak ridges, evergreen hammocks, and sandstone outcrops in a variety of sandy soil conditions ranging from moist to very dry
Pondspice *Litsea aestivalis*	No Federal Status	T	Margins of swamps, cypress ponds, and sandhill depression ponds and in hardwood swamps

[1]This species is the responsibility of the National Marine Fisheries Service.

Listed Species in McIntosh County (updated May 2004)				
Species	**Federal Status**	**State Status**	**Habitat**	**Threats**
Mammal				
Humpback whale *Megaptera novaeangliae*	E	E	Coastal waters during migration	Entanglement in commercial fishing gear and collisions/disturbance associated with boats and barges
Right whale *Eubalaena glacialis*	E	E	Mate and calve in shallow coastal waters; critical habitat designated from the mouth of Altamaha River south to Sebastian Inlet, FL (from shoreline east 5-15 nautical miles)	Initial decreases probably due to overharvesting. Slow population growth after exploitation halted may be due to collisions/disturbance associated with boats and barges, inbreeding, inherently low reproductive rates, or a reduction in population below a critical size for successful reproduction.
West Indian manatee *Trichechus manatus*	E	E	Coastal waters, estuaries, and warm water outfalls	Initial decreases probably due to overharvesting for meat, oil and leather. Current mortality due to collisions with boats and barges and from canal lock operations. Declines also related to coastal development and loss of suitable habitat, particularly destruction of seagrass beds.
Bird				
Bachman's warbler *Vermivora bachmanii*	E	E	Probably extinct; last seen in Georgia in 1976	
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia. The Georgia Department of Natural Resources maintains a hack site for eagles in the County. Active eagle nests were located in McIntosh County 1992-1999 and 2000-2002.	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Gull-billed tern *Sterna nilotica*	No Federal Status	T	Nests in colonies on sandy sites; forages over salt marsh, dunes and other grassy areas for insects, spiders, and other invertebrates	
Piping plover *Charadrius melodus*	T	T	Winter on Georgia's coast; prefer areas with expansive sand or mudflats (foraging) in close proximity to a sand beach (roosting)	Habitat alteration and destruction and human disturbance in nesting colonies. Recreational and commercial development have contributed greatly to loss of breeding habitat.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Wood stork *Mycteria americana*	E	E	Primarily feed in fresh and brackish wetlands and nest in cypress or other wooded swamps. Active rookeries were located in McIntosh County 1991-2002.	Decline due primarily to loss of suitable feeding habitat, particularly in south Florida. Other factors include loss of nesting habitat, prolonged drought/flooding, raccoon predation on nests, and human disturbance of rookeries.
Invertebrate				
Altamah spinymussel *Elliptio spinosa*	Candidate Species	E	species is NOT state-listed according to GA DNR website + phone call to DNR @ 770-918-6411 12/21/05	
Reptile				

Eastern indigo snake *Drymarchon corais couperi*	T	T	During winter, den in xeric sandridge habitat preferred by gopher tortoises; during warm months, forage in creek bottoms, upland forests, and agricultural fields	Habitat loss due to uses such as farming, construction, forestry, and pasture and to overcollecting for the pet trade
Gopher tortoise *Gopherus polyphemus*	No Federal Status	T	Well-drained, sandy soils in forest and grassy areas; associated with pine overstory, open understory with grass and forb groundcover, and sunny areas for nesting	
Green sea turtle *Chelonia mydas*	T	T	Rarely nests in Georgia; migrates through Georgia's coastal waters	Exploitation for food, high levels of predation, loss of nesting habitat due to human encroachment, hatchling disorientation due to artificial lights on beaches, and drownings when trapped in fishing and shrimping nets
Hawksbill sea turtle *Eretmochelys imbricata*	E	E	Migrates through Georgia's coastal waters	Primary causes of population decline are development and modification of nesting beaches and exploitation for the shell. Secondary causes include egg consumption, use of the skin for leather, and heavy predation of eggs and hatchlings.
Kemp's ridley sea turtle *Lepidochelys kempi*	E	E	Migrates through Georgia's coastal waters	Overharvesting of eggs and adults for food and skins and drowning when caught in shrimp nets
Leatherback sea turtle *Dermochelys coriacea*	E	E	Rarely nests in Georgia; migrates through Georgia's coastal waters	Human exploitation, beach development, high predation on hatchlings, and drowning when caught in nets of commercial shrimp and fish trawls and longline and driftnet fisheries
Loggerhead sea turtle *Caretta caretta*	T	T	Nests on Georgia's barrier island beaches; forages in warm ocean waters and river mouth channels	Loss of nesting beaches due to human encroachment, high natural predation, drownings when turtles trapped in fishing and shrimping trawls, and marine pollution
Amphibian				
Flatwoods salamander *Ambystoma cingulatum*	T	T	Adults and subadults are fossorial; found in open mesic pine/wiregrass flatwoods dominated by longleaf or slash pine and maintained by frequent fire. During breeding period, which coincides with heavy rains from Oct.-Dec., move to isolated, shallow, small, depressions (forested with emergent vegetation) that dry completely on a cyclic basis. Active breeding site found in McIntosh County since 1990.	Habitat destruction as a result of agricultural an silvicultural practices (e.g., clearclutting, mechanical site preparation), fire suppresion and residential and commercial development.
Fish				
Shortnose sturgeon[1] *Acipenser brevirostrum*	E	E	Atlantic seaboard rivers	Construction of dams and pollution, habitat alterations from discharges, dredging or disposal of material into rivers, and related development activities.
Plant				
Climbing buckthorn *Sageretia minutiflora*	No Federal Status	T	Calcareous rocky bluffs, forested shell middens on barrier islands, and evergreen hammocks along streambanks and coastal marshes	
Narrowleaf obedient plant	No Federal Status	T	Wet muck or peat in shallow water of river swamp openings and in the margins of both fresh and brackish (tidal) marshes	

Physostegia leptophylla			
Pondspice *Litsea aestivalis*	No Federal Status	T	Margins of swamps, cypress ponds, and sandhill depression ponds and in hardwood swamps

[1]This species is the responsibility of the National Marine Fisheries Service.

Listed Species in Glynn County
(updated May 2004)

Species	Federal Status	State Status	Habitat	Threats
Mammal				
Humpback whale *Megaptera novaeangliae*	E	E	Coastal waters during migration	Entanglement in commercial fishing gear and collisions/disturbance associated with boats and barges
West Indian manatee *Trichechus manatus*	E	E	Coastal waters, estuaries, and warm water outfalls	Initial decreases probably due to overharvesting for meat, oil and leather. Current mortality due to collisions with boats and barges and from canal lock operations. Declines also related to coastal development and loss of suitable habitat, particularly destruction of seagrass beds.
Bird				
Bachman's warbler *Vermivora bachmanii*	E	E	Probably extinct; last seen in Georgia in 1976	
Bald eagle *Haliaeetus leucocephalus*	T	E	Inland waterways and estuarine areas in Georgia. Active eagle nests were located in Glynn County 1992 - 1999 and 2000-2002	Major factor in initial decline was lowered reproductive success following use of DDT. Current threats include habitat destruction, disturbance at the nest, illegal shooting, electrocution, impact injuries, and lead poisoning.
Gull-billed tern *Sterna nilotica*	No Federal Status	T	Nests in colonies on sandy sites; forages over salt marsh, dunes and other grassy areas for insects, spiders, and other invertebrates	
Kirtland's warbler *Dendroica kirtlandii*	E	E	Migrate through Georgia to wintering grounds in the Bahamas	Small population numbers, limited distribution on the breeding and wintering grounds, exacting breeding habitat requirements, and cowbird parasitism
Piping plover *Charadrius melodus*	T	T	Winter on Georgia's coast; prefer areas with expansive sand or mudflats (foraging) in close proximity to a sand beach (roosting)	Habitat alteration and destruction and human disturbance in nesting colonies. Recreational and commercial development have contributed greatly to loss of breeding habitat.
Red-cockaded woodpecker *Picoides borealis*	E	E	Nest in mature pine with low understory vegetation (<1.5m); forage in pine and pine hardwood stands > 30 years of age, preferably > 10" dbh	Reduction of older age pine stands and encroachment of hardwood midstory in older age pine stands due to fire suppression
Wood stork *Mycteria americana*	E	E	Primarily feed in fresh and brackish wetlands and nest in cypress or other wooded swamps. Active rookeries were located in Glynn County 1991-1998 and 2000-2002.	Decline due primarily to loss of suitable feeding habitat, particularly in south Florida. Other factors include loss of nesting habitat, prolonged drought/flooding, raccoon predation on nests, and human disturbance of rookeries.
Reptile				
Eastern indigo snake *Drymarchon corais couperi*	T	T	During winter, den in xeric sandridge habitat preferred by gopher tortoises; during warm months, forage in creek bottoms, upland forests, and agricultural fields	Habitat loss due to uses such as farming, construction, forestry, and pasture and to overcollecting for the pet trade
Gopher tortoise *Gopherus polyphemus*	No Federal Status	T	Well-drained, sandy soils in forest and grassy areas; associated with pine overstory, open understory with grass and forb groundcover, and sunny areas for nesting	

Green sea turtle *Chelonia mydas*	T	T	Rarely nests in Georgia; migrates through Georgia's coastal waters	Exploitation for food, high levels of predation, loss of nesting habitat due to human encroachment, hatchling disorientation due to artificial lights on beaches, and drownings when trapped in fishing and shrimping nets
Hawksbill sea turtle *Eretmochelys imbricata*	E	E	Migrates through Georgia's coastal waters	Primary causes of population decline are development and modification of nesting beaches and exploitation for the shell. Secondary causes include egg consumption, use of the skin for leather, and heavy predation of eggs and hatchlings.
Kemp's ridley sea turtle *Lepidochelys kempi*	E	E	Migrates through Georgia's coastal waters	Overharvesting of eggs and adults for food and skins and drowning when caught in shrimp nets
Leatherback sea turtle *Dermochelys coriacea*	E	E	Rarely nests in Georgia; migrates through Georgia's coastal waters	Human exploitation, beach development, high predation on hatchlings, and drowning when caught in nets of commercial shrimp and fish trawls and longline and driftnet fisheries
Loggerhead sea turtle *Caretta caretta*	T	T	Nests on Georgia's barrier island beaches; forages in warm ocean waters and river mouth channels	Loss of nesting beaches due to human encroachment, high natural predation, drownings when turtles trapped in fishing and shrimping trawls, and marine pollution
Fish				
Shortnose sturgeon[1] *Acipenser brevirostrum*	E	E	Atlantic seaboard rivers	
Plant				
Ball-moss *Tillandsia recurvata*	No Federal Status	T	Branches of live oak in Georgia, especially near the coast	
Climbing buckthorn *Sageretia minutiflora*	No Federal Status	T	Calcareous rocky bluffs, forested shell middens on barrier islands, and evergreen hammocks along streambanks and coastal marshes	
Pondspice *Litsea aestivalis*	No Federal Status	T	Margins of swamps, cypress ponds, and sandhill depression ponds and in hardwood swamps	

[1]This species is the responsibility of the National Marine Fisheries Service.

Wiltz 1982

V-043

VOGTLE ELECTRIC GENERATING PLANT
BEAVERDAM CREEK ANADROMOUS FISH STUDY, BURKE COUNTY,
GEORGIA FROM MARCH, 1977, THROUGH MAY, 1978
OPERATING LICENSE STAGE ENVIRONMENTAL REPORT
TECHNICAL DOCUMENT

J. WAYNE WILTZ
PRINCIPAL INVESTIGATOR

GEORGIA POWER COMPANY
ENVIRONMENTAL AFFAIRS CENTER

OCTOBER, 1982

LIST OF FIGURES

VEGP - OLSER

INTRODUCTION

Construction of the Vogtle Electric Generating Plant (VEGP) began in June, 1974, and was discontinued in September, 1974, as a result of unfavorable economic conditions. Construction resumed in January, 1977, with excavation activities beginning in February. The plant site is approximately 3169 acres located in Burke County on the southwest side of the Savannah River, the natural boundary between Georgia and South Carolina. The site is at river mile 150.9 across from the Savannah River Plant (SRP) operated by E. I. DuPont DeNemours and Company for the U.S. Department of Energy. The plant site is approximately 26 miles south-southeast of Augusta, Georgia. The site is located in the coastal plain, which is characterized by sandy or sandy loam soil with rolling hills and mixed pine-hardwood association. Since the onset of construction, approximately 1391 acres of the site have been cleared for plant construction.

The original plans proposed a generating plant consisting of four units, but construction of two units has been cancelled. The plant will employ two pressurized water reactors producing 1160 MW each. Unit 1 is scheduled to go into service in March, 1987, and Unit 2 in September, 1988. The exhaust steam will be cooled by a closed-cycle cooling system employing natural draft cooling towers using make-up water from the Savannah River. Low volume waste and blowdown from both cooling towers will ultimately be discharged back into the river.

The Savannah River below Augusta, Georgia, and above the VEGP site receives wastewater discharges from municipalities and industries that add organic wastes, nutrients, metals, and other trace contaminants. Stream classification near the VEGP is listed as "Fishing."[1] The river near the plant site is typical of large southeastern coastal plain rivers except that a dredged channel is maintained by the Corps of Engineers for barge traffic. The biological community of the river is similar to that of other large southeastern rivers but has been affected by man's influence on the river. The impoundment of the river above Augusta, Georgia, has reduced the transport of sediments and allochthonous particulate organic materials, and the dredging of the channel has reduced the natural shallow areas and backwaters that would normally support a diverse flora and fauna. Studies on the Savannah River flora and fauna have been conducted periodically since 1951 and were detailed in Patrick, et al.,[2] Academy of Natural Sciences of Philadelphia,[3][4] and Matthews.[5]

Georgia Power Company was required by the Plant Vogtle Final Environmental Statement, issued by the United States Atomic Energy Commission,[6] to complete the requirement that the extent of use of Beaverdam Creek by anadromous fishes for spawning be established and that the effects of construction on spawning be determined. A study began in March, 1977, and ended in May, 1978.

The creek is approximately six miles in length and flows east-northeast to its confluence with the Savannah River at approximate river mile 148.4. Daniels Branch, a creek approximately five miles in length, flows southeast and High Head Creek, approximately one mile in length, flows northeast with both joining Beaverdam Creek in Telfair Pond (figure 1). Telfair Pond originated with the damming of Beaverdam Creek below the confluence of three creeks.

Game and commercially important anadromous fishes found in the Savannah River in Georgia include the Atlantic sturgeon (Acipenser oxyrhynchus), blueback herring (Alosa aestivalis), hickory shad (Alosa mediocris), American shad (Alosa sapidissima), and the striped bass (Morone saxatilis). The shortnose sturgeon (Acipenser brevirostrum) has been reported by the State of South Carolina in the Savannah River. It is on the federal[7] and State of Georgia[8] endangered and threatened species lists.

METHODS

One permanent station, Station 1.0 (figure 1), was sampled weekly beginning March 2 and ending May 3, 1977, and from March 7 to May 3, 1978. Because of flooding in 1977, surveys could not be conducted the weeks of April 4 to 8 or April 25 to 29. When river levels decreased so that sampling could be continued, the spawning in Beaverdam Creek by anadromous fishes was completed. The April 14, 1977, survey was conducted approximately 1 to 1½ miles upstream from the mouth of Beaverdam Creek due to the elevated river level. In contrast, river levels were low in 1978, allowing continuous weekly sampling.

Adult fish in 1977 were sampled using 2, 3, and 4-inch stretch mesh gill nets set at dusk and collected at dawn the following day. A hoop net with blockoff wings was used in the 1978 study, set for the same duration of time. Specimens which could be positively identified in the field and were not needed for the reference collection were released. Other specimens were preserved in a ten percent formalin solution and were taken to the Environmental Affairs Center in Decatur, Georgia.

Larval fish and eggs in 1977 were sampled with a ½ x ½ m net and a 1-m diameter drift net with a 760 micron mesh. Samples were collected at three locations across the creek. The net was placed on the bottom for a 15-minute duration. In 1978, two surveys were conducted using the ½ x ½ m net at two locations for 15 minutes each, but was later changed to one sample using a 1-m diameter drift net taken in the middle of the creek on the bottom for two hours. This proved to be more effective in procurring eggs and larvae. Samples were preserved in the field with ten percent formalin.

Physicochemical data collected in conjunction with the biological data included air and water temperatures, dissolved oxygen, pH, and light penetration. A YSI Model 54 oxygen meter was used to measure air and water temperatures and dissolved oxygen. A Beckman Electromate pH meter was used in 1977 and an Orion Ionalyzer Model 399A in 1978. Light penetration was measured using a secchi disc.

RESULTS AND DISCUSSION

The family, scientific, and common names of all fishes including resident species collected during the anadromous fish study are given in table 1.

The Atlantic sturgeon, according to Breder and Rosen,[9] spawned at water temperatures of 13.3 C (56 F) and above, which agrees with Scott and Crossman,[10] who stated that the species spawned at temperatures of 13.3 to 17.8 C (54 to 64 F). The spawning site was "over a hard bottom of clay, rubble, gravel, or shell in shallow running water or water up to five fathoms deep; possibly in pools below waterfalls."[11] The Atlantic sturgeon spawned in water over a hard, clay bottom.[10][11] The shortnose sturgeon spawned in the middle reaches of large tidal rivers in the spring.[10][12] The striped bass spawned in tidal-fresh or slightly brackish water in large rivers with a high discharge in April and May.[9][13][14] Spawning sites and temperatures for the American shad, hickory shad, and blueback herring showed some differences according to the available literature. The American shad spawned at temperatures of 12 to 20 C in the mainstream of a river near the mouths of tributaries and creeks and rarely, if ever, in lakes.[11][13][16] Street[15] reported blueback herring spawned in swamps and lakes at temperatures of 15 to 20 C and not the main channel in the Altamaha River, Georgia, which contradicted the findings of Loesch and Lund[16] that they were highly selective and preferred fast-flowing water and associated hard substrate but not standing water. Hickory shad spawned in the Altamaha River at temperatures of 12 to 26 C in large tributaries and lakes and not in the mainstream of the river.[15]

Water temperatures during the study period ranged from 10 to 22 C for 1977 and from 8.9 to 21 C for 1978. The Atlantic sturgeon has not been collected in Beaverdam Creek, although larvae have been collected in drift samples from the Savannah River. Beaverdam Creek did not appear to be suitable for spawning for this species. The creek bottom consisted of drifting sand which did not concur with the spawning habitats for the Atlantic sturgeon.[10][11] Shortnose sturgeon, striped bass, and American shad, because of their preference in spawning sites, did not utilize Beaverdam Creek. Hickory shad and blueback herring were more likely to spawn in the creek. This was indicated by the numbers collected during the study (tables 2 and 3) and by the literature search. Blueback herring seemed best suited for spawning in the creek because the physical conditions of the creek were similar to those described by Loesch and Lund.[16] Water temperatures were optimum for spawning beginning in mid-March to early April, and the _Alosa_ spp. eggs collected in the drift samples (tables 4 and 5) fit the description of blueback herring.

The low numbers of alosids collected may have indicated a low utilization of Beaverdam Creek and the adjacent Savannah River for spawning. "Upstream distribution is more likely a function of seeking desirable spawning sites," stated Loesch and Lund.[16] Davis and Cheek[17] noted that blueback herring have spawned as far as 134.8 miles upstream in the Cape Fear River, North Carolina. Beaverdam Creek is located approximately 150.0 miles from the mouth of the Savannah River. Loesch[18] also noted that different areas of a brook were used for spawning, depending on the rainfall and runoff intensities. Loesch and Lund[16] found that during periods of drought, spawning was not observed in tributaries with reduced flow. The low numbers of species and individuals collected, especially alosids in 1978, may have indicated the effects of low rainfall[19] thus low river elevations. Figure 2 presents the monthly precipitation for the Augusta area for January through May 1977 and 1978 and the record mean values for those months.

Secchi disc readings ranged from 15.4 to greater than 39.0 inches in 1977 and from 31.3 to greater than 39.0 inches in 1978. The creek was muddy only for short periods after heavy rainfall or when the creek flow was reversed because of the backflow of the river water as in 1977. Dissolved oxygen ranged from 6.6 to 10.0 ppm in 1977 and from 6.9 to 10.0 ppm in 1978; pH ranged from 5.5 to 7.7 and from 6.2 to 7.2, respectively for 1977 and 1978.

CONCLUSION

Because of the low number of eggs and adults collected in the gill net, hoop net, and larval drift survey, the conclusion was Beaverdam Creek provided minor use for spawning for blueback herring. Physical characteristics notable creek bottom composition and flow made the creek unsuitable for spawning for the remaining anadromous species except the hickory shad. No reason can be given that would explain why hickory shad did not spawn in Beaverdam Creek.

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TABLE 1 (PAGE 1 OF 2)

FAMILY, SCIENTIFIC, AND COMMON NAMES OF FISHES COLLECTED
DURING THE 1977-1978 BEAVERDAM CREEK ANADROMOUS FISH STUDY

Scientific Name	Common Name	1977	1978	Totals
GILL NET AND HOOP NET SURVEY				
Lepisosteidae				
Lepisosteus osseus	Longnose gar	14	3	17
Lepisosteus platvrhincus	Florida gar	3		3
Amiidae				
Amia calva	Bowfin	9		9
Anguillidae				
Anguilla rostrata	American eel		1	1
Clupeidae				
Alosa aestivalis	Blueback herring	44	10	54
Alosa mediocris	Hickory shad	17		17
Alosa sapidissima	American shad	7		7
Dorosoma cepedianum	Gizzard shad	12	4	16
Catostomidae				
Erimyzon oblongus	Creek chubsucker	1	2	3
Minytrema melanops	Spotted sucker	22	1	23
Moxostoma anisurum	Silver redhorse	1		1
Ictaluridae				
Ictalurus brunneus	Snail bullhead	4	31	35
Ictalurus catus	White catfish	2		2
Ictalurus natalis	Yellow bullhead	4		4
Ictalurus nebulosus	Brown bullhead	3		3
Ictalurus platycephalus	Flat bullhead	10		10
Ictalurus punctatus	Channel catfish	5	1	6
Centrarchidae				
Centrarchus macropterus	Flier		1	1
Lepomis auritus	Redbreast sunfish	1	7	8
Lepomis macrochirus	Bluegill	1	9	10
Lepomis microlophus	Redear sunfish		2	2
Micropterus salmoides	Largemouth bass	3		3
Pomoxis annularis	White crappie	1		1
Pomoxis nigromaculatus	Black crappie	3	3	6
Mugilidae				
Mugil cephalus	Striped mullet		1	1
DRIFT NET SURVEY				
Clupeidae				
Alosa spp. eggs	Shad	2	58	60
Cyprinidae				
Notropis cummingsae	Dusky shiner	1		1
Notropis lutipinnis	Yellowfin shiner	1		1
Notropis petersoni	Coastal shiner	7		7
Opsopoeodus emiliae	Pugnose minnow	1		1

TABLE 1 (PAGE 2 OF 2)

Scientific Name	Common Name	1977	1978	Totals
Catostomidae				
Erimyzon spp. *larvae*	Chubsucker		1	1
Percidae				
Percidae eggs	Darter		7	7
Percidae larvae	Darter	77	37	114

VEGP - OLSER

TABLE 2

SAMPLING DATES AND NUMBER OF INDIVIDUALS COLLECTED IN THE GILL NET SURVEYS FOR 1977

Species	March 2	March 9	March 17	March 22	March 31	April 14	April 19	May 3	Number of Individuals
Amia calva		5							5
Lepisosteus osseus			1	1	1	2		9	14
Lepisosteus platyrhincus								3	3
Alosa aestivalis	2	4	19	17	2				44
Alosa mediocris	7	5	1	4					17
Alosa sapidissima		1	2	3			1		7
Dorosoma cepedianum	2	1	4	3	1			1	12
Erimyzon oblongus						1			1
Minytrema melanops	10		5	2		1	2	2	22
Moxostoma anisurum			1						1
Ictalurus catus			1		1				2
Ictalurus brunneus			1	2	1				4
Ictalurus natalis						4			4
Ictalurus nebulosus			3						3
Ictalurus platycephalus			1	1		3	5		10
Ictalurus punctatus		1	2	2					5
Lepomis auritus						1			1
Lepomis macrochirus	1								1
Micropterus salmoides	2					1			3
Pomoxis annularis						1			1
Pomoxis nigromaculatus		2	1						3
Totals	24	19	42	35	6	14	8	15	163

VEGP - OLSER

TABLE 3

SAMPLING DATES AND NUMBER OF INDIVIDUALS COLLECTED IN THE HOOP NET SURVEYS FOR 1978

Species	March 7	March 14	March 21	March 28	April 4	April 10	April 17	April 24	May 3	Number of Individuals
Lepisosteus osseus					1	1		1		3
Anguilla rostrata									1	1
Alosa aestivalis		1			9					10
Dorosoma cepedianum	1	2			1					4
Erimyzon oblongus			1	1						2
Minytrema melanops	1									1
Ictalurus brunneus		4	26	1						31
Ictalurus punctatus									1	1
Centrarchus macropterus	1									1
Lepomis auritus	2		4		1					7
Lepomis macrochirus	2		2		3		1		1	9
Lepomis microlophus							1		1	2
Pomoxis nigromaculatus		1		2						3
Mugil cephalus								1		1
Totals	7	8	33	39	15	1	2	2	4	76

TABLE 4

TAXA COLLECTED DURING THE 1977 BEAVERDAM CREEK ANADROMOUS FISH STUDY (DRIFT SURVEY)

	Sampling Dates									
Taxa	March 2	March 8-9	March 16-17	March 22-23	March 30-31	April 4-8	April 13-14	April 19	May 3	Totals
Alosa spp. eggs	(a)	(a)	2		(b)	(b)		(b)		2
Percidae larvae				1			68		8	77
Notropis lutipinnis Adult							1			1
Notropis petersoni Adult							7			7
Opsopoeodus emiliae Adult			1							1
Totals			3	1			76		8	88

a. No species collected
b. No survey

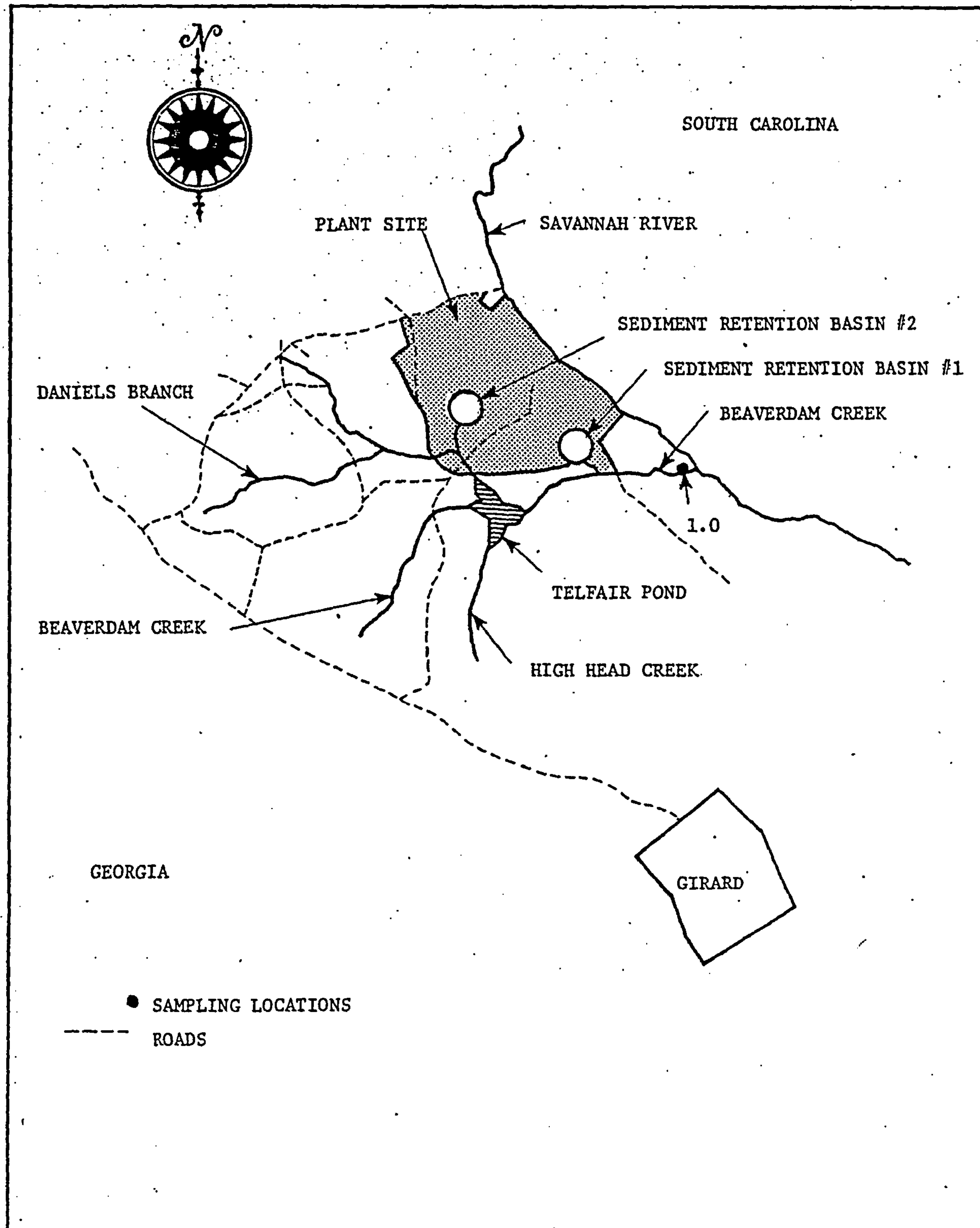
VEGP - OLSER

TABLE 5

TAXA COLLECTED DURING THE 1978 BEAVERDAM CREEK ANADROMOUS FISH STUDY (DRIFT SURVEY)

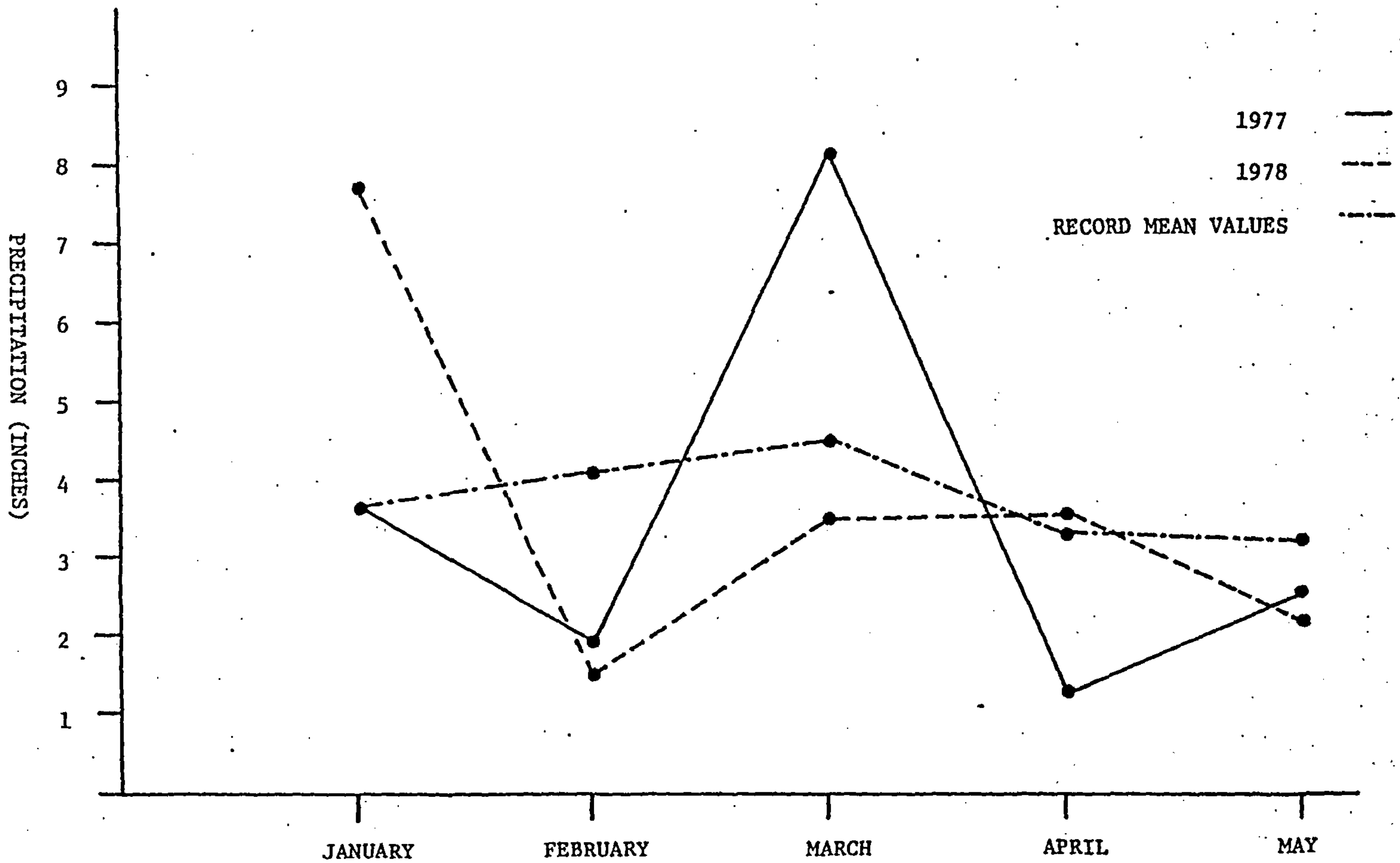
	Sampling Dates									
Taxa	March 7	March 14	March 21	March 28	April 4	April 10	April 17	April 24	May 3	Totals
Alosa spp. eggs	(a)	(b)	(b)		57	1				58
Percidae eggs							5	2		7
Percidae larvae					13	8	6	9	1	37
Erimyzon spp. larvae								1		1
Notropis cummingsae Adult					1					1
Totals					71	9	11	12	1	104

a. No survey
b. No species collected



Georgia Power — VOGTLE ELECTRIC GENERATING PLANT UNIT 1 AND UNIT 2	STATION LOCATION FOR THE BEAVERDAM CREEK ANADROMOUS FISH STUDY
	FIGURE 1

433-9



Georgia Power

VOGTLE
ELECTRIC GENERATING PLANT
UNIT 1 AND UNIT 2

COMPARISON OF MONTHLY PRECIPITATION FOR THE AUGUSTA AREA FOR JANUARY THROUGH MAY 1977 AND 1978

FIGURE 2

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CURRENT STATUS OF ENDEMIC MUSSELS IN THE LOWER OCMULGEE AND ALTAMAHA RIVERS

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V-544

Abstract. The Altamaha River Basin is well known among malacologists for its high percentage (ca. 40%) of endemic mussels. While little historical data exists to quantify changes in mussel abundance, many biologists believe that some species are declining. We assembled a large database of mussel occurrence records from surveys conducted since 1967 and used this data to assess the current status of endemic mussels in the lower Ocmulgee and Altamaha rivers. The percentage of sites occupied and the ranges of the Altamaha arcmussel, Altamaha spinymussel, and inflated floater have declined over the past 10 years. The remaining endemic mussel species occupy a large percentage of sites and appear to be stable. We recommend the development of a long-term monitoring program for Altamaha basin endemic mussels. Success of this program will require both probability-based sampling to estimate mussel density and detection probabilities along with qualitative sampling to document occurrences at new sites.

INTRODUCTION

Freshwater mussels are important components of aquatic ecosystems as they provide food for many species and filter algae and bacteria from large volumes of water. They are also important indicators of ecosystem health due to their sensitivity to human disturbances. Unfortunately, many of these species are declining as a result of incompatible land use practices, impoundment of rivers, and the introduction of non-native species

Freshwater mussels reach their greatest diversity in the southeastern United States. Ninety-eight mussel species are historically known from Georgia. Neves et al. (1997) indicated that seventy-one species are considered imperiled, with 25 species listed as threatened or endangered under the United States Endangered Species Act (USESA). Seven of Georgia's eight endemic mussel species occur only in the Altamaha Basin. Three endemics, the Altamaha arcmussel (*Alasmidonta arcula*), Altamaha spinymussel (*Elliptio spinosa*), and inflated floater (*Pyganodon gibbosa*) are thought to be declining in abundance, while four other endemic mussels appear to stable. As a result, the current status of the endemic mussels of the lower Altamaha River system was reviewed. This review will provide information to policy makers and regulatory agencies for developing conservation strategies that may affect the persistence and habitat quality of imperiled mussels.

BACKGROUND

The Altamaha River Basin is the largest basin in Georgia (36,976 km^2). Major tributaries in the basin include: the Ocmulgee, Oconee, and Ohoopee rivers (Figure 1). Although historic collections date back to the 1830's, most major surveys have been conducted since the late 1960's (Sickel 1969; Keferl 1981; O'Brien 2002; Skelton et. al. 2002). Sixteen mussel species are reported from these surveys, including seven species that are considered endemic to the basin (Table 1). Several additional, but undescribed species have also been documented from the basin but are not considered in this review (Gene Keferl pers. comm.; Skelton 2004).

The Altamaha spinymussel was recognized as a candidate for listing under the USESA in 2002. The Altamaha arcmussel and the inflated floater have also been recognized as imperiled or vulnerable to imperilment in several conservation assessments (Neves et al. 1997; O'Brien 2002). Elevation of the Altamaha spinymussel to candidate status coupled with the presumed decline of other mussel species has prompted intensive mussel surveys throughout the Altamaha River and its tributaries since 2000. Results from these surveys were compiled in order to assess the current status of the endemic mussels of the Altamaha Basin.

METHODS

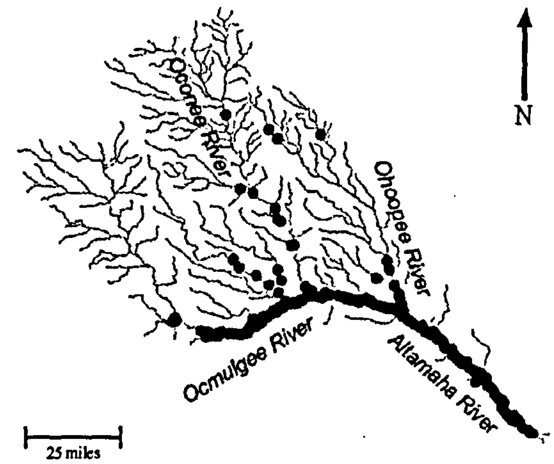
Mussel surveys conducted between 1967 and 2004 were incorporated into a GIS database (Figure 1). This database contained detailed locality information, habitat descriptions, and qualitative or quantitative data on the abundance of each mussel species collected at each survey site. This database was used to determine the percentage of sites occupied by each endemic species. The data were also used to assess changes in the linear extent of occupied habitat. All analyses were based on live individuals.

We used all collection records to calculate the percentage of sites occupied before and after 2000. Since a large number of collections occurred from 1990 to 1995 and from 2000 to 2004, we also conducted a test for a temporal change in the number of sites occupied between these two time periods (Strayer and Smith 2003). For each site that was sampled during both time periods, we determined if the site was occupied during the first period but not the second (hereafter an "extinction") or occupied during the second period but not the first (hereafter a "colonization"). We then compared the frequency of extinctions and colonizations with a chi-square test evaluated at alpha = 0.10. The assumption of the test was that sampling efforts are comparable between the two time periods. This assumption was evaluated by comparing the number of collections made at each site during the two time periods. Although timed effort was not available for all sites, we also compared the mean number of person-minutes spent searching for mussels during each collection. Lastly, gross changes in the linear extent of occupied habitat were examined by comparing the upstream and downstream extent of occurrences before and after 2000. If the upstream and downstream extent of occurrences differed by 10 km or less, the linear range of the species was not considered to have changed between the two time periods. This analysis was limited to a subset of the study area where extensive survey points were located during both time periods.

RESULTS

The database included collection records from 241 sites sampled before 2000 and 120 sites sampled after 2000. Most sites occurred between the Ocmulgee River near Jacksonville, GA and the Altamaha River near Darien, GA before 2000; however, sites sampled after 2000 extended only to Doctortown, GA. Sites also occurred in the Oconee and Ohoopee rivers and smaller tributaries prior to 2000 (Figure 1). Thus, range assessments were restricted to the linear extent of occupied habitat between Jacksonville downriver to Doctortown. Data collected from recent surveys on the Ohoopee River (Stringfellow and Gagnon 2001) and the Little Ocmulgee River (Skelton 2004) are not included in any of the quantitative analyses.

Thirty-nine sites that were sampled during the first period were resampled after 2000. These sites extended



from the Ocmulgee River near Lumber City, GA downstream to Doctortown on the Altamaha River. Fifty surveys were completed before 2000 and 51 were completed after 2000 (several sites were surveyed repeatedly). In addition, the mean person-minutes spent searching sites was similar between the two sampling periods, indicating that assumption of comparable sampling effort between the periods was met.

Overall, the percentage of sites occupied by the Altamaha arcmussel was low during both periods, but fewer sites were occupied after 2000 (Table 1). Declines were evident when considering the 39 sites that were used sampled during the early 1990s and early 2000s (Table 2). In fact, this species was presumably extirpated from more sites than any other mussel species. Prior to 2000, Altamaha arcmussels occurred upstream to approximately Jacksonville. However, after 2000, no live individuals were collected within a 15 km reach downstream of Jacksonville. The downstream extent of occupied habitat did not change between the two time periods.

The percentage of sites occupied by the Altamaha spinymussel was also low, but did not decline when all records were compared (Table 1). However, analysis of the 39 sites indicated that the spinymussel was lost from significantly more sites than it colonized between the early 1990's and the early 2000's (Table 2). The linear extent of occupied habitat of this species did not appear to change between the two time periods.

The percentage of sites occupied declined more for inflated floaters than for any other mussel species (Table 1). In addition, this species was represented at few overall sites. The inflated floater was lost from more sites than it colonized after 2000, but this was not statistically significant. The downstream extent of its range did not differ after 2000, but the upstream extent of its range decreased by 37 km.

The Altamaha slabshell, Altamaha lance, Georgia elephantear, and Altamaha pocketbook occurred at a relatively high percentage of sites before (36-56 %) and after 2000 (66-87%; Table 1). All of these species showed increases (18-49%) in the percentage of sites occupied between the two time periods (Table 1). There was no evidence to suggest that the number of sites occupied by any of these species declined among the 39 sites sampled in the early 1990's and 2000's (Table 2). In addition, the upstream and downstream extent of occurrences did not change after 2000 for any of these species.

DISCUSSION AND RECOMMENDATIONS

The Altamaha arcmussel, Altamaha spinymussel, and inflated floater are rare throughout the lower Ocmulgee and Altamaha Rivers. Synthesis of recent data indicates that the percentage of sites occupied within these rivers has declined since the early 1990's. The linear extent of occupied habitat in the Ocmulgee River has declined for the Altamaha arcmussel and inflated floater. While range contractions were not documented for the Altamaha spinymussel, Stringfellow and Gagnon (2001) failed to collect this species from Ohoopee River sites that were occupied in the early 1990's. Although the inflated floater is rare within the mainstem habitats that were targeted in these surveys, the habitat preferences of this species suggest that backwaters and oxbows should be targeted in future surveys. The remaining endemic species appear to be stable throughout the lower Ocmulgee and Altamaha Rivers.

We recommend the development of a long-term monitoring program for Altamaha basin mussels. The database we developed for this assessement will provide a useful foundation for such a program and should be continually updated. The presence-absence analyses we carried out may also be useful in future assessments. Because this procedure examines both colonizations and extirpations, it allows for more informed assessments than those that only compare occupancy rates at historically known sites. Future assessments can be improved by using methods that allow estimation of detection probabilities and mussel densities. Finally, our database illustrates a need for additional or updated surveys in the Oconee River, the Ocmulgee River above Jacksonville, The Altamaha River below Doctortown, and many tributary streams.

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This work could not have been completed without the efforts of Eugene Keferl, Christine O'Brien, Chris Skelton, Christi Lambert, Carson Stringfellow and many others who have assisted with mussel surveys.

Table 1. Number and percent of sites occupied by Altamaha basin mussels before and after 2000. Site occupancy is based on surveys conducted at 241 sites sampled before 2000 and 120 sites sampled after 2000

		Site Occupancy			
		Pre-2000		Post-2000	
Scientific Name	Common Name	Sites	%	Sites	%
Alasmidonta arcula	Altamaha arcmussel	52	22	19	16
Elliptio dariensis	Georgia elephantear	87	36	80	67
Elliptio hopetonensis	Altamaha slabshell	136	56	90	75
Elliptio shepardiana	Altamaha lance	116	48	79	66
Elliptio spinosa	Altamaha spinymussel	24	10	14	12
Lampsilis dolabraeformis	Altamaha pocketbook	90	37	104	87
Pyganodon gibbosa	Inflated floater	40	17	7	6

Table 2. Presence-absence data for 39 sites that were sampled from 1990-1995 and from 2000-2004. The number of sites occupied during the first period (Present), the number of sites occupied during the first period but not the second (Extinctions), and the number of sites occupied during the second period but not the first (Colonizations) are reported each species. The frequency of colonizations and extinctions was compared using a using a X^2 test with alpha=0.10.

Common Name	Present	Colonizations	Extinctions	X^2	P-Value
Altamaha arcmussel	27	1	22	17.4	<0.001
Georgia elephantear	28	4	6	0.1	0.751
Altamaha slabshell	35	3	6	0.4	0.505
Altamaha lance	35	3	7	0.9	0.343
Altamaha spinymussel	13	3	11	3.5	0.061
Altamaha pocketbook	32	6	3	0.4	0.505
Inflated floater	12	3	9	2.1	0.150

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