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GEORGIA POWER
A SOUTHERN COMPANY

April 6, 2011

Ms. Magalie R. Salas
Secretary, Federal Energy Regulatory Commission
888 First Street, NE Room 1-A
Washington, D.C. 20426

RE: ROBUST REDHORSE REPORT VOLUME 7
SINCLAIR HYDROELECTRIC PROJECT (FERC NO. 1951)

Dear Ms. Salas:

Please find enclosed a report entitled Conservation and Restoration of the Robust Redhorse *Moxostoma robustum*, Volume 7, submitted in partial fulfillment of the requirements of Article 404 of the above-referenced license. This report is the sixth in a series of reports to be submitted every two years, on the status of the robust redhorse and the adequacy of flow releases in meeting the needs of this species.

The first report, Volume 1, was submitted in 1998, Volume 2 in 2000, Volume 3 in 2002, Volume 4 in 2004, Volume 5 in 2006, and Volume 6 in 2008. These reports documented increased knowledge of the species' life history and progress toward conservation throughout the historic range. The current report, Volume 7, updates the status of robust redhorse and documents continued expansion of this cooperative conservation effort across state lines and jurisdictional boundaries. Volume 7 includes summary information and associated attachments describing general robust redhorse conservation activities across its range and specific management and research activities for the Oconee population during 2009 and 2010.

Data suggests the Oconee River robust redhorse population is relatively stable but very low in number since 2001. Annual monitoring surveys of robust redhorse are continuing, utilization of habitat enhancement areas is underway, and studies related to spawning, larval abundance, and hatchery propagation have been completed. Currently, wild populations exist in the Ocmulgee and Oconee rivers (Georgia), Savannah River (Georgia and South Carolina), and the Pee Dee River drainage (North and South Carolina). Successful reproduction has been documented in wild populations, however documenting recruitment success continues to be challenging. Successful stocking in the Broad and Ogeechee rivers in Georgia and the Broad and Wateree rivers of South Carolina has created additional populations, but it is not known if these populations will sustain themselves over time. Monitoring programs for all wild and introduced populations are currently in place or under review.

At present, it is uncertain if the existing flow regime in the Oconee River at Sinclair Dam is benefiting robust redhorse, and the Flow Advisory Team is working to determine if altering Sinclair Project flows is warranted.

If you have any questions or comments on this report, please contact me at 404/799-2159.

Sincerely,

Joe E. Slaughter IV

Joe E. Slaughter, IV
Fisheries Biologist

enclosures

Conservation and Restoration of the Robust Redhorse *Moxostoma robustum* in the Oconee River, Georgia

Volume 7

April 2011

prepared for the

Federal Energy Regulatory Commission
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ACKNOWLEDGEMENTS

This report was based on the work of many individuals and organizations too numerous to name that form the Robust Redhorse Conservation Committee. Specifically, I thank Jimmy Evans from the Georgia Department of Natural Resources, Alice Lawrence and Jaci Zelko from the U.S. Fish and Wildlife Service, and Cecil Jennings from the U.S. Geologic Survey, Georgia Cooperative Fish and Wildlife Research Unit for their ongoing commitment to robust redhorse conservation in the Oconee River and the state of Georgia. I also thank Ryan Heise from the North Carolina Wildlife Resources Commission, Dave Coughlan from Duke Energy, and Forrest Sessions and Scott Lamprecht from the South Carolina Department of Natural Resources for their contributions to this report and for their commitment to robust redhorse conservation throughout the species' native range. Without this collaborative effort, few of the accomplishments outlined herein would have been possible.

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1. Introduction

This report is the seventh report in a series of bi-annual reports required by the Federal Energy Regulatory Commission (FERC) license for Georgia Power Company's (GPC) Sinclair Hydroelectric Project (FERC No. 1951). Article 404 of the Sinclair Project license, issued by the FERC on 19 March 1996 (effective date 1 May 1996), requires the submission of a progress report every two years to the FERC, "*which summarizes the status of the robust redhorse and makes a determination on the adequacy of flow releases in meeting the needs of this species*."

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, Volume 2,* was submitted to the FERC in April 2000 and was limited to conservation activities that occurred from June 1998 through April 2000. *Conservation and Restoration of the Robust Redhorse, Volume 3,* was submitted to the FERC in May 2002 and was limited primarily to activities that occurred between June 2000 and April 2002. *Conservation and Restoration of the Robust Redhorse, Volume 4,* was limited to activities that occurred between April 2002 and May 2004, *Conservation and Restoration of the Robust Redhorse, Volume 5,* was limited to activities between May 2004 and May 2006, and *Volume 6* described activities from March 2007 through December 2008.

This reporting period begins in January 2009 and continues through mid-March 2011. The format of this report has been modified similar to that of *Volume 6* such that greater emphasis is placed on recent activities than on previously documented and reported work. More thorough discussions of activities prior to 2007 can be found in *Volume 5* and in information maintained at the RRCC website, www.robustredhorse.com.

The material for this report was gathered from many sources, including complete and incomplete project reports, RRCC updates, letters, personal communications, and oral presentations.

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 ichthyologists.

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 Edward Cope from specimens collected in the Yadkin River, NC. Unfortunately, Cope’s original specimens were lost, and labels from those specimens were mistakenly applied to another species. Over the next 100 years, the 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. Those two specimens were believed to belong to an undescribed species of redhorse. The discovery of the Oconee River population of robust redhorse helped to clarify the description of this species.

In August 1991, biologists from the Georgia Department of Natural Resources (GA-DNR) collected five large 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 (UGA) fish collection, and Dr. Robert Jenkins of Roanoke College, Virginia, worked to identify the specimens. They concluded the five specimens from the Oconee River were the same species as the two existing specimens collected in 1980 and 1985, and all these specimens belonged to the species originally described by Cope in 1870. The currently accepted historic range consists of southeastern Atlantic slope rivers, extending from the Altamaha River system in Georgia to 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 concern was that fish collections from the Oconee River showed a population comprised primarily of larger individuals (all greater than 400 mm TL), prompting concerns about a senescing population or some other problems that might be affecting recruitment of robust redhorse. The concerns included artificial flows from power generation, erosion and siltation, and introduced predatory species such as flathead catfish.

1.3 Robust Redhorse Conservation Committee

The 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 currently accepted former range. The primary goals of the RRCC are to implement research and conservation measures, enhance recruitment in existing populations, and re-establish robust redhorse populations in appropriate river systems within the species' former range.

The RRCC directs recovery efforts for the robust redhorse and sets priorities for necessary research and action building on previous results. Through collaborative information and resource sharing among members and other interested parties, the RRCC has identified potential threats to the species, conducted research related to those threats, 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.

Mr. Forrest Sessions of South Carolina DNR served as the 7th Chair of the RRCC from October 2008 through October 2010. Ryan Heise of the North Carolina Wildlife Resources Commission is the current Chair and will serve in that capacity through 2012. While some individual representatives have changed, member organizations comprising the Executive Committee (Excom) have remained the same since 2005. Those members include the Georgia Department of Natural Resources (GA DNR), South Carolina Department of Natural Resources (SC DNR), North Carolina Wildlife Resources Commission (NC WRC), US Fish and Wildlife Service (USFWS), United States Geological Survey (USGS), Georgia Power Company (GPC), Duke Energy, Progress Energy and representatives from Academia among others.

Memorandum of Understanding
The MOU's purpose is to establish and describe the RRCC. The first MOU was approved in 1995 and expired December 31, 2004. The MOU was revised, became effective Jan 1, 2005, and again expired December 31, 2009. The current operating version of the MOU became effective on January 1, 2010 and expires December 31, 2015. No changes to the MOU have been made since the 2005 revision.

Robust Redhorse Conservation Strategy
The Robust Redhorse Conservation Strategy (Strategy) describes the extent of 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. No changes to the Conservation Strategy have been made since its approval in 2003.

Robust Redhorse Conservation Committee: Policies
The RRCC has developed a policy document, adopted October 18, 2002, which unifies practices and activities of member organizations needed to implement the long- and short-term goals established in the Strategy. These policies also provide a framework for the development of individual management plans for specific robust redhorse populations. In general, the policies are organized such that consistency among goals, conservation activities, and administration of the RRCC are maintained at all levels.

1.4 Candidate Conservation Agreement with Assurances for the Robust Redhorse: Ocmulgee River, Georgia

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 a rare species with potential to require future listing under the Endangered Species Act (ESA) could be problematic. In this case, the RRCC needed a sound approach for effectively handling one of the most critical components of the conservation effort.

One approach, published by the USFWS in 1999 (64 Federal Register 32726-32736 and 50 C.F.R. §§ 13 and 17), was the use of Candidate Conservation Agreements with Assurances (CCAA). CCAAs promote conservation actions by encouraging partnerships between private entities and state and federal natural resources agencies to protest rare species with the goal of addressing potential threats to their survival. 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 ESA.

The Ocmulgee River, a candidate site for reintroduction, provided an opportunity for applying the CCAA policy. The upper reaches of the Ocmulgee River are influenced by generation from GPC's Lloyd Shoals Hydroelectric facility, which has a 30-year FERC license expiring January 1, 2024. During relicensing, minimum flow was increased to enhance aquatic habitat, and a labyrinth weir was constructed to improve dissolved oxygen concentrations in the river. GA DNR, USFWS, and the RRCC determined that the 18 mile reach downstream of Lloyd Shoals Dam was suitable habitat for a proposed reintroduction. Since that time, the weir has been removed adding habitat and connectivity within the dam tailrace, and water quality has been greatly improved with the installation of passage aeration devices in penstock draft tubes.

GPC has invested considerable time and dollars on environmental enhancements to the upper Ocmulgee River and believed these enhancements would also benefit any potential robust redhorse population. However, GPC also believed that a reintroduction of robust redhorse potentially represented an undefined risk to the Lloyd Shoals facility, if the species was federally listed under the ESA. GPC expressed these concerns to GA DNR and the USFWS, and those disccusions ultimately led to a CCAA for the robust redhorse (Candidate Conservation Agreement with Assurances for the Robust Redhorse (*Moxostoma robustum*), Ocmulgee River, Georgia, 2001).

Under the CCAA, GPC agreed to support specific conservation actions following introduction by the Georgia DNR, including funding for telemetry studies on the reintroduced fish, surveys, and population estimates. In return, GPC received assurances that if the robust redhorse is 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. The assurances are 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 can be structured as a cooperative effort to benefit the species. It is believed that this CCAA for the robust redhorse was the second CCAA implemented in the United States. It was also the first CCAA to involve an aquatic species and a private company.

1.5 Flow Advisory Team for the Oconee River

The Flow Advisory Team for the Oconee River (Advisory Team) is implemented under Article 404 of the Sinclair license. The current members of the Advisory Team are the GA-DNR, GPC, Georgia Wildlife Federation (GWF), USFWS, and USGS. 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 reviews 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 (implemented June 1996) 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. The effects of this flow regime are discussed further below.

Table 1 Negotiated flow agreement for the 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) utilized, depending on inflow into the reservoir
[b] from June 1-10, units are operated run-of-river unless electric system demands necessitate normal peaking operation. The agreement also provides for an increase in generation (from 5 to 7 days per week) to reduce extended low-flow periods that previously resulted from little weekend generation.

2. Current Rangewide Species Status

Currently, robust redhorse populations exist in the Oconee, Ocmulgee, Ogeechee, and Broad Rivers, Georgia; in the Savannah River, Georgia and South Carolina; in the Broad and Wateree Rivers, South Carolina; and in the Pee Dee River drainage, North and South Carolina (Figure 2). The Oconee, Savannah, and Pee Dee populations are native, while the remaining five are introduced.

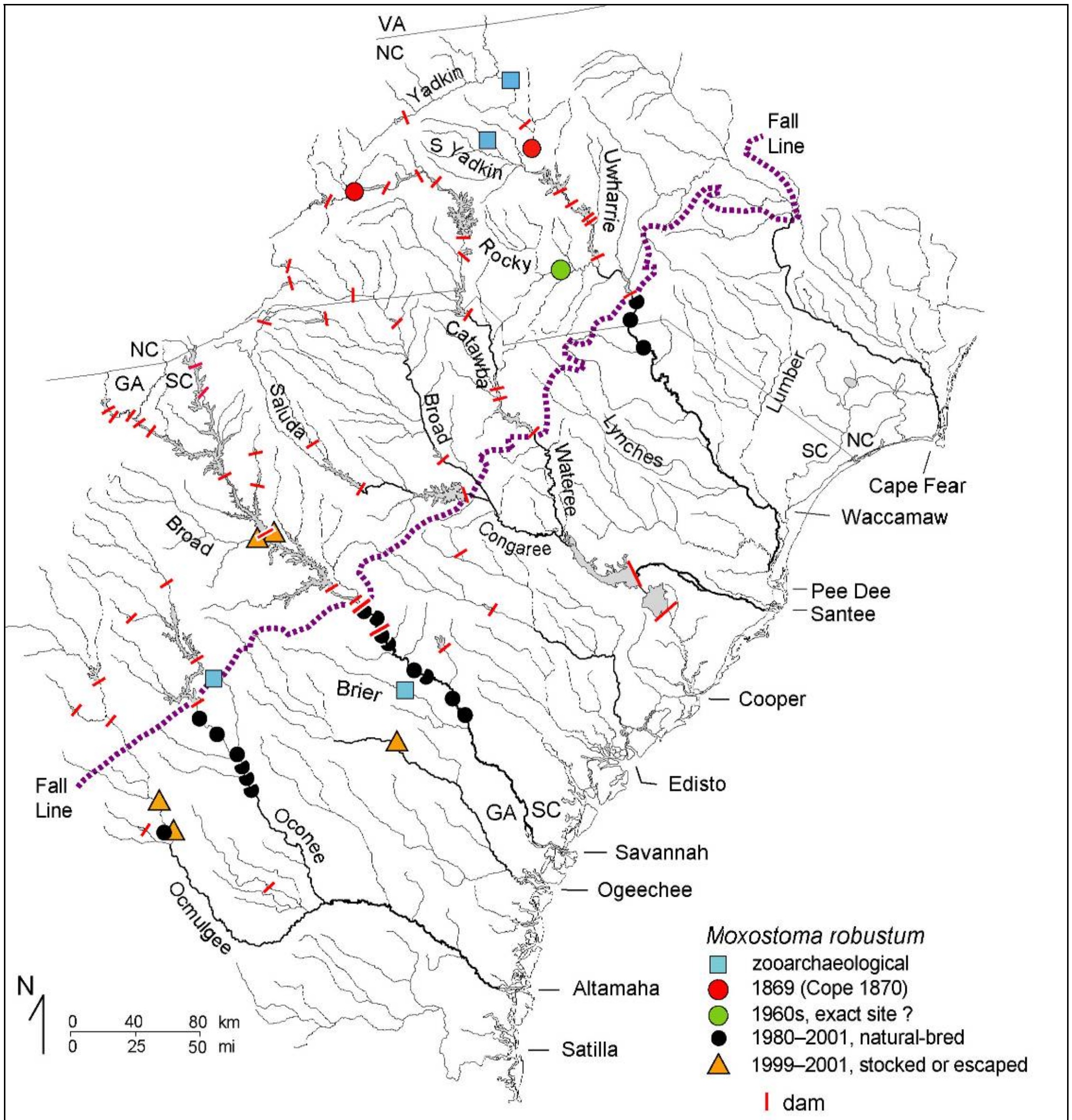

Fig. 00. Robust redhorse records of natural-bred fish (squares and circles); and of artifically-bred fish (triangles) captured after stocking or escape from rearing ponds. Dams shown mainly for larger streams (south of Cape Fear drainage). Savannah R. sites of the 4 record symbols crossed by dam symbols 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. Map of the current range of robust redhorse in Georgia, South Carolina, an North Carolina.

2.1 Oconee River Population (GA)

Most information on the status of the Oconee River population is based on selective electro-fishing along a 30 river mile section during spring broodfish collection from 1994 to 2010. During broodfish collection and other studies on the Oconee River between 2002 and 2010, catch rates of adult fish decreased from previous years, and no juveniles or young-of-year were collected. Adult population estimates have also declined over this time period. A more in depth discussion of the Oconee River population status is included below in Section 3. A summary of the results from a recently completed telemetry study is also included as Appendix 1.

2.2 Ocmulgee River Population (GA)

Activities associated with robust redhorse conservation in the Ocmulgee River are described in an update to FWS in Appendix 2. To date, 13,734 robust redhorse representing 10 year classes have been stocked into the Ocmulgee River below Lloyd Shoals Dam. In 2009, an untagged juvenile robust redhorse was collected in the Ocmulgee just upstream of Juliette, GA, possibly resulting from spawning by stocked individuals or potentially indicating the presence of a small relict population in the upper Ocmulgee River or its tributaries.

2.3 Broad, Wateree, and Savannah River Populations (SC)

South Carolina's efforts have involved stocking fingerlings from Savannah River-strain broodstock. South Carolina has stocked the Broad River, SC every year since 2004 (over 50,000 fingerlings stocked to date) and the Wateree River every year since 2005 (over 15,000 fingerling and advanced fingerlings stocked to date. All fish were either tagged with coded-wire tags or P.I.T. tags, and mature fish of hatchery origin have been collected in both rivers. The goal for these stockings was to introduce progeny from 100 reproducing pairs. Through 2009, offspring from 98 individual crossings had been produced. In 2010, an additional 17 individual crosses produced over 25,000 larvae, but harvest of hatchery rearing ponds was extremely low. In order to achieve the target 100 individual crosses, SCDNR will continue hatchery production in 2011. Once the 100 crosses target is met, all activities will shift to an "evaluation" period and future stocking will be either postponed or terminated (Forrest Sessions and Scott Lamprecht, SC DNR, personal communication and unpublished data, April 2011).

Since first introduced into the Wateree River, SC, in 2005, collections of robust redhorse have steadily increased each spring. Electrofishing efforts for diadromous fish below the Wateree Dam each spring have noted increasing numbers and sizes of robust redhorse. The maximum size of robust redhorse, the number of fish, and the number of sexually mature fish have increased each spring. The collections indicate that the SCDNR’s relocation effort has been initially very successfully. While triads of mature adults have been collected during spring in the Wateree River, at this time, no wild juveniles have been collected (Dave Coughlan, Duke Energy, personal communication, March 2011).

2.4 Yadkin/Pee Dee River Population (NC)

The North Carolina Wildlife Resources Commission and Progress Energy have recently entered into a flow agreement providing increased minimum flows below Blewett Falls Dam in the Pee Dee River. As such, population level monitoring for robust redhorse has been suspended for four to five years allowing the robust redhorse population time to respond to the new flow regime. In 2010, a collaborative tracking study was launched in the system by SCDNR, NCWRD, and Progress Energy to identify new spawning sites resulting from higher winter/spring flows. While robust redhorse did migrate upstream within the system, there appeared to be no significant response to the higher flows, and robust redhorse continued to utilize the same known spawning sites (Unpublished data provided by Ryan Heise, NC Wildlife Resources Commission, March 2011).

2.5 Broad River Population (GA)

Four year classes (n = 32,189) were stocked in the Broad River, GA, between 1995 and 1998 from the Oconee River stock. Although populations are not expected to mix due to Clark Hill Reservoir, stocking halted after the incidental collection of a single robust redhorse from the native Savannah River population in October 1998. At present, the population in the Broad River (GA) is stable. A telemetry study is currently being conducted in the Broad by Dr. Bud Freeman at the University of Georgia.

2.6 Ogeechee River Population (GA)

A total of 43,048 robust redhorse from 7 year classes have been stocked into the Ogeechee River to date. 2008 electrofishing surveys yielded 34 individuals representing five year classes and a catch rate of 5.0 fish/hour. Of those robust redhorse stocked in the Ogeechee, 75 were relocated into the Oconee in 2007 and 2008 to supplement the Oconee population and for use in an ongoing telemetry study. The Ogeechee population continues to be an excellent refugial population and source of fish for stocking, research, and propagation efforts (Jimmy Evans GA DNR, personal communication).

In late-2010, a telemetry study began in the Ogeechee to determine habitat use and spawning site selection by the recently created population. Below is a summary provided by Patrick Ely and Cecil Jennings of the USGS Georgia Cooperative Fish and Wildlife Research Unit, Athens, Georgia in a project update on March 10, 2011.

> *Between November 2010 and March 2011, we conducted 10 electrofishing trips to the Ogeechee River and have collected, tagged, and released 19 robust redhorse. One robust redhorse was captured on 01 December 2010, three were captured on 23 February 2011, seven were captured on 02 March 2011, and eight were caught on 09 March 2011. We will continue electrofishing for robust redhorse until we have a total of thirty radio tagged individuals. The radio-tagged fish will be tracked weekly during the spring spawning season. These data should help identify where in the system robust redhorse are spawning and allow for habitat characterization and protection of spawning site(s). After the spawning season, 10 sampling stations will be established and sampled during the summer and fall to ascertain the abundance of juvenile robust redhorse in the system.*

3. Status of the Oconee River Population through 2010

The Oconee River robust redhorse population has been sampled extensively since 1991. In general, sampling strategies have been diverse in nature and technique, and have targeted various life stages and numerous habitat types within the system. Some of the most rigorous sampling efforts have targeted adult robust redhorse during their spawning aggregation and subsequent migrations to known spawning areas within the river. Other sampling surveys have been conducted in proposed spawning locations (i.e. in locations where suitable gravel substrate and flow velocities exist for spawning activity), in meander/bend sections of river where studies have suggested that robust redhorse preferred habitats exist (i.e., outside bends and pools associated with moderate flows and woody debris), and in various other habitats where surrogate species studies and laboratory experimentation has suggested that the species might reside. With these studies, numerous datasets have been developed, and results from those data have been highly variable.

The two most consistent long-term datasets for analysis of adult population status have resulted from broodfish collection for propagation activities and exploratory monitoring surveys designed to identify additional spawning aggregates or spawning locations. While targeted collections at known spawning sites were highly productive at the onset of species monitoring, collections of adult robust redhorse at those sites has steadily declined over time. Causes of this decline are unclear, but several hypotheses seem to fit. The first hypothesis is that the adult robust redhorse population originally sampled in abundance in the early 1990's was senescing, and recruitment of juveniles was slow or nonexistent. Another potential cause of the decline is a shift in spawning location driven by either repeated sampling/handling at known sites, change of the known sites to a point where they no longer supported large-scale spawning activities, or shifts in preferred locations due to changes in flow (including changes in flow regime related to drought). Instream flow conditions in the Oconee River might also have led to the apparent decline in spawning aggregate abundance at known sites, since the population was relatively stable prior to the flow change and has clearly declined since the implementation of the current flow regime in 1995 (Figure 3). Flathead catfish abundances within the Altamaha Basin have also steadily increased since their discovery in the system in 1970's, and with their increase comes increased predation potential above and beyond that of the existing predator community. Any or all of these factors, coupled with numerous years of excessive drought, may have ultimately led to the continued decline in adult robust redhorse collections at known spawning sites.

For long-term monitoring purposes, targeted broodfish/spawning adult collections and the resulting data may be somewhat biased in that only those fish actively spawning or moving onto the spawning bar are collected and included. Those targeted collections might also be misleading if flows change resulting in missed spawning cues or if the condition of the known spawning sites becomes degraded over time. Spawning site collections also may not incorporate suitable effort, gears, or location for collecting non-spawning or lesser dominant individuals. To best understand the status of the population in its entirety, the right combination of gear type(s), sampling location(s), and seasonality must be achieved. To that end, we have analyzed data from the Oconee River collected during monitoring and exploratory surveys, generally using consistent methods (i.e. electrofishing gears and techniques), and collected during Spring of each year to address the current status of the population, provide context for future management, provide insight on enhancing the monitoring program, and set up a long-term database from which causation of the population's apparent decline can be addressed.

Current Status

During 2009, population estimates were revised corresponding to a revision and cleaning of the Oconee River robust redhorse database. These revised population estimates are depicted in Figure 3. The Oconee population remained largely unchanged from 1995 through 2000 with population estimates ranging from 300-500 individuals annually. A significant decrease was noted however from 1999 to 2002, resulting in an almost 70% decline in the population. From 2001-2004, the population remained largely unchanged with approximately 100 adult robust redhorse estimated to reside within the reach of the Oconee River from Black Creek to Dublin. Since 2004, population estimates have been mathematically unattainable due to low catch rates.

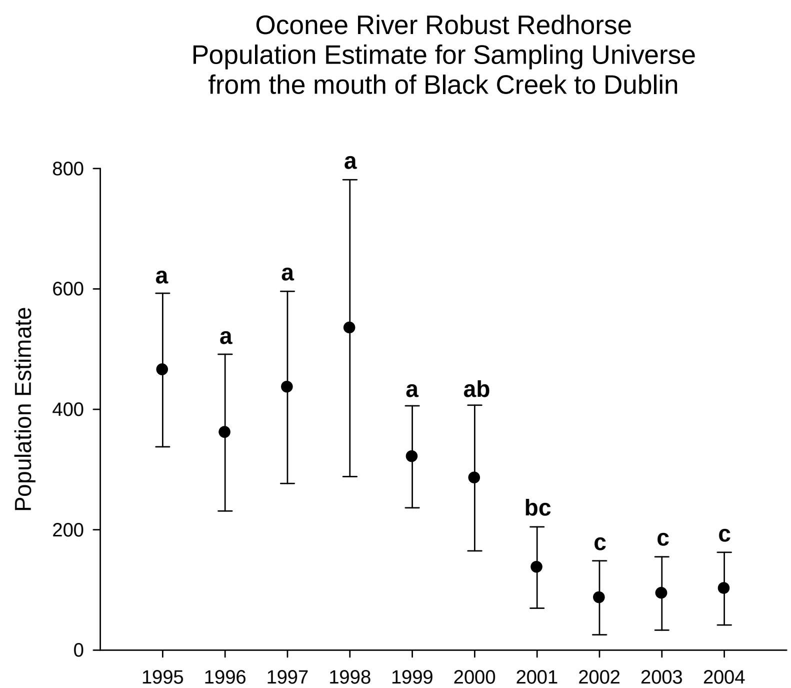

Figure 3. Mark-recapture population estimates of adult robust redhorse in the Oconee River, GA from 1995-2005. Error bars around estimates depict standard error of the calculated estimate. Letters for each year indicates statistical significance.

Since *Volume 6* of this report, few new data have been collected on the existing robust redhorse population in the Oconee River. In 2009, no robust redhorse were captured in the Oconee River in six hours of electrofishing effort. As such, the Oconee TWG designed an intensive monitoring survey for Spring 2010 to cover the entire reach of Oconee River between Sinclair Dam and Dublin. Unfortunately, the 2010 survey was only partly completed due to extreme weather conditions producing significant rainfall and localized flooding, resulting in a second consecutive year of no robust redhorse collections in the Oconee River.

For 2011, the Oconee TWG has proposed to place emphasis on the following objectives or tasks:

1. GADNR standardized spring electrofishing sampling from the Avant Kaolin Mine to the mouth of Black Creek.
2. Monitor robust redhorse use of gravel augmentation sites
    a. Periodic visual observations for spawning activity
    b. Audible observations using hydrophones
    c. Collection, identification, and enumeration of larvae
3. Sample upper reaches of the Oconee River upstream of Wallace Dam/Lake Oconee

These objectives are in line with those priority management actions outlined in the finalized Oconee River management plan, completed in 2010 and included as Appendix 3.

4. Additional Related Activities

4.1 Oconee River Telemetry Study

The Oconee River telemetry study was completed by the USGS GA-Coop Unit in 2010. A summary of that project is included in Appendix 1.

4.2 Gravel Augmentation and Spawning Bar Creation

GA-DNR has continued creation and augmentation of gravel bars on the Oconee River in an effort to increase suitable spawning substrate for robust redhorse and other species. Since 2009, DNR has installed over 1000 tons of gravel forming bars totaling roughly 2.5 acres spread among four sites in Washington, Wilkinson, Johnson, and Laurens Counties. These bars were created in areas where depth and flow velocities were similar to those found in known spawning areas and with substrates believed to be suitable to sustain the gravel deposits over time.

Tracking and electrofishing surveys were conducted in 2010 to monitor use of these gravel bars by robust redhorse and other species. While no robust redhorse were documented to have utilized these sites for spawning in 2010, numerous larval fish and some native mussels were observed. DNR intends to continue monitoring of augmentation sites each spring in order to assess the long-term success of the project.

5. Flow Suitability for Oconee River Robust Redhorse

Members of the Flow Advisory Team have been actively involved in the creation of an Oconee River Management Plan (ORMP) and have directed much of their time and effort towards that task. The ORMP addresses all facets of robust redhorse conservation within the Oconee and identifies gaps in research, directs future research and management activities, and is designed to be adaptive in its consideration of flow effects. With the completion of the ORMP, the Flow Advisory Team has begun compiling the results of recent research projects relating instream flows to various aspects of Moxostoma sp. life history in order to create a succinct flow recommendation. No timeline is currently available for the completion of that recommendation, but it is a primary objective for the coming year.

At present, it appears that conservation activities in the Oconee River have not enhanced or stabilized the declining Oconee robust redhorse population. Population estimates and catch rates continue to decline, in spite of stocking and modified flows. While the current flow regime from Sinclair Dam was designed to benefit various life stages of the species, the robust redhorse's continued decline perhaps suggests that flow and habitat availability may not have been the primary factors leading to the decline of the species.

In the Ocmulgee River, robust redhorse appear to be doing well, although it is presently uncertain if a long-term sustainable population has been created. GPC's Lloyd Shoals Dam is operated in a manner similar to the previous flow regime at Sinclair prior to 1996 (i.e. continuous 400 cfs minimum flow or inflow at Lloyd Shoals). Given the apparent success of conservation efforts in the Ocmulgee under a less restrictive flow regime, perhaps greater attention should be directed at other possible sources of robust redhorse decline, and required flows from Sinclair Dam should be modified back to a lower minimum flow level with fewer seasonal restrictions. A modification of this type would also fit the adaptive management framework of the ORMP, such that a change in flow regime similar to that of Lloyd Shoals could be monitored closely over a three to five year period of time and response of the Oconee robust redhorse population to that flow regime change could be adequately documented. This type of real-world experimentation would lead to better knowledge of the population's response to flow changes than any habitat suitability model or any flow strategy designed from incomplete data representing only a single life stage with little or no ability to account for temporal variability over longer time steps.

One major obstacle for any flow related experimentation describing the robust redhorse response to system alteration is the inability to effectively sample the populations. As described in Appendix 2, while robust redhorse are known to exist in various places within the Ocmulgee River, electrofishing sampling is difficult due to limited access to areas where the species aggregates, and typical boat electrofishing techniques in more accessible areas have shown a substantially low capture probability (as described by Grabowski and Jennings and included in Volume 6 of this report; see Appendix 2 for a more complete discussion and references). Coupling ineffective sampling techniques for determining population status with the life history strategy of the species (i.e. long-lived and relatively slow to maturity), experimentation with flow regimes is problematic. For example, if a flow regime is created to benefit the robust redhorse, it could be five or more years before the population responds due to slow growth rates and longer time to maturity. Even then, with low capture probabilities for our current methodologies, the current monitoring program might not be able to detect the population response. While attempts have been made by Oconee TWG members to identify more effective sampling techniques and gears, to date, none have proven successful at improving capture rates for the species.

6. Future Directions for Oconee River Robust Redhorse Conservation

Understanding the causes of the decline in the Oconee River robust redhorse numbers represents the most important future direction for the species' recovery. While restoration effort in most of the native range have been highly successful in spite of full understanding of causation, the Oconee River has not responded as well to those same techniques. Drawing parallels and analyzing difference between the Oconee and other populations is important, but equally important is active experimentation into specific causes in the decline in the Oconee. Adaptive conservation strategies with real-world experimentation provide an opportunity for direct measures of success and virtually instantaneous changes to the strategy in the event of failure or setbacks. With the successful advancement of hatchery propagation techniques, coupled with the successful establishment of refugial populations with good genetic diversity, risks associated with adaptive management are minimized.

Attention for future efforts within the Oconee River will also likely include the exploration of habitats above GPC's Wallace Dam in the upper Piedmont Ecoregion portion of the basin. Success in North Carolina of reintroduction efforts coupled with Cope's original description of the species' range and preferred habitat, are largely driving that interest. Also, Wallace and Sinclair dams are an obstacle to flathead catfish movements in the basin, and the upper reaches of the Oconee River might contain suitable habitat with lower predation pressure. Prior to any effort to stock robust redhorse in the upper Oconee, complete surveys of both fish fauna and available habitat will need to be conducted. Those studies should also consider fundamental questions like 'why are robust redhorse not already here?' before any attempt is made to recreate or establish a population.

Habitat restoration activities will continue for the foreseeable future, and study of current project success should guide future efforts. Regardless whether habitat is limiting for robust redhorse, rapid human population expansion, increased development, and increased demands for water in the region have necessitated improvement and protection of aquatic habitats. Also, with the institution of the National Fish Habitat Initiative and resulting partnerships, like the Southeastern Aquatic Resource Partnership (SARP), new funding has become available to enhance and protect degraded habitats within highly developed watershed.

Finally, the partnership among members of the Robust Redhorse Conservation Committee will continue to guide robust redhorse conservation efforts throughout its range. Each year, the committee recaps lessons learned through management and research, and refocuses on steps for the following year or years. The Oconee River robust redhorse population is of the highest priority with the Committee, and restoring the population of robust redhorse within the river is among its highest goals.

Appendix 1

Movements and habitat use of robust redhorse stocked into the Oconee River, Georgia

Summary Report

Patrick Ely
Georgia Cooperative Fish and Wildlife Research Unit,
Warnell School of Forestry and Natural Resources,
University of Georgia

Cecil Jennings
US Geological Survey,
Georgia Cooperative Fish and Wildlife Research Unit,
Warnell School of Forestry and Natural Resources,
University of Georgia

March 10, 2011

Summary

We used radio telemetry to assess seasonal habitat use and movement patterns of adult robust redhorse stocked in the Oconee River downstream of Milledgeville, GA. Thirty three hatchery-produced robust redhorse from Oconee River broodstock were captured in the Ogeechee River, transported to the Oconee River, anesthetized, implanted with radio transmitters, and released. Within two weeks of release, 79% of robust redhorse traveled upstream of the release site; some even traveling ~40 km upstream near the historic Avant mine spawning site. After spawning season, the tagged fish generally moved downstream to varying degrees. Movement was limited to about 9 km during the summer (July – August 2008-09) and winter (December – February 2008-10) periods. During fall 2008 (Sept – Nov), fish movement increased to ~52 km and movement was generally in a downstream directions with some intermittent upstream movements. This was probably a delayed exploratory response related to an increase in water level and a decrease in water temperature following summer drought conditions. In contrast, during fall 2009 (Sept – Nov), movement was only about 15 km. In late-October 2009, three fish were tracked over a 24-hr period and relocated at 2-hr intervals. Movement averaged 0.15 km (± 0.07 SE) at night and 0.44 km (± 0.19 SE) during the day but without obvious directionality.

In the winter of 2008-09, following a minor flooding event, an individual who had been last located the previous fall went undetected in the Oconee River. Tracking for this individual was extended downstream the entire length of the Altamaha River without success. During the pre-spawning period of 2009, tracking continued into the Ocmulgee River where the fish was relocated on 05 March 2009 approximately 65 km upstream of the confluence. That individual later re-entered the Oconee River and was detected on 25 March 2009 just south of Dublin, GA, an approximate absolute distance of 143 km from its previous location.

During the 2009 & 2010 spring/pre-spawn period (March – April), 100% of the fish migrated upstream toward the Avant mine area. In mid-April 2009 during this migration, four fish were tracked over a 24-hour period and relocated at 2-hr intervals. Movement averaged 1.34 km (± 0.65 SE) at night and 6.07 km (± 1.95 SE) during the day in an upstream direction. During the 2009 & 2010 spawning periods, robust redhorse were located near the Avant mine site, but none were located on the historic gravel bar. However, in 2009, an aggregate of tagged fish was located about 1.4 km upstream of the Avant mine site at an oxbow "cut through" that contained

gravel substrates. Within a 0.2 km radius of the “cut through”, seven individuals (50% of remaining tagged fish) were located at least once, and three were located multiple times. During the 2010 spawning season, none of the remaining tagged fish were relocated in the “cut through” area, and gravel substrates were not detected at the site. During the 2009 spawning season, another aggregate of tagged fish was located in a 1-km stretch of river containing gravel substrates. This section of river was located ~2 km downstream of the Avant mine site. Six different individuals (43% of remaining tagged fish) were located here at least once and three were located multiple times. During the 2010 spawning season, two individuals (67% of remaining tagged fish) were located in this same stretch of river and gravel substrates were still present.

Robust redhorse were consistently found in the main channel associated with fast current (0.47 m/s ± 0.01 SE), relatively deep water (2.26 m ± 0.04 SE), sandy substrates, and woody debris. Annual linear home range estimates for robust redhorse averaged 43.2 km and ranged from 26.6 km to 77.0 km. Annual kernel density core area home range estimates averaged 9.5 km (range: 2.3 km – 28.6 km) and indicated that a majority of our radio-tagged robust redhorse primarily occupied the ~ 25 km section of river between the Avant mine site and the Oconee trestle throughout the year.

Appendix 2

Environmental Laboratory
5131 Maner Road
Smyrna, GA 30080

(404) 799-2159

GEORGIA POWER
A SOUTHERN COMPANY

March 17, 2011

Ms. Alice Lawrence,
U. S. Fish and Wildlife Service
Westpark Center, Suite D
105 Westpark Drive
Athens, Georgia 30606

Dear Ms. Lawrence:

The enclosed is a summary of the conservation actions conducted during 2010 for the Candidate Conservation Agreement with Assurances for the Robust Redhorse, *Moxostoma robustum*, Ocmulgee River, Georgia, (CCAA) as described in Agreement Number 1448-40181-01-K-005. This report summarizes activities conducted during 2009 towards fulfillment of phases 1 and 2 of the CCAA. Specific activities addressed include monitoring the abundance and distribution of introduced robust redhorse (Conservation Action 3) and monitoring the adult population in the Ocmulgee River and estimating population size (Conservation Action 4), as a result of our January 2008 modification to the CCAA.

Please contact me at 404-799-2159 if you have further questions regarding this report.

Sincerely,

Joe E. Slaughter, IV
Fisheries Biologist
Georgia Power Company

XC:
With attachments.

Jimmy Evans, Georgia Department of Natural Resources
Cecil Jennings, USGS Georgia Cooperative Fish and Wildlife Research Unit
Ryan Heise, Chairman Robust Redhorse Conservation Committee
Hallie Meushaw, Troutman Sanders
Joel Galt, Southern Company Generation, Hydro Services
Greg Brown, Georgia Power
Cheryl Wheeler, Georgia Power
Mike Phillips, Georgia Power

2010 Progress Report: Candidate Conservation Agreement with Assurances for the Robust Redhorse, *Moxostoma robustum*, Ocmulgee River, Georgia

Agreement Number 1448-40181-01-K-005

Conservation Action 1. *Georgia DNR will stock the Project Site with approximately 4,000 hatchery-reared robust redhorse fingerlings each year for five years*.

On January 3, 2008, the FWS issued a modification to the CCAA, which allows GPC to move forward with Conservation Actions 3 and 4 under the Adaptive Management provision without reaching the original stocking target of 20,000 fingerlings. As such, no formal stocking program is currently underway, and the final stocking event (26 individuals from five year classes representing the last of the adult captive broodstock at Warm Springs FNH) took place in 2009.

Conservation Action 2. *Georgia Power will fund two surveys, one in year 1 (2002) and one in year 3 (2004) on the movement of introduced juvenile robust redhorse.*

A third movement survey was completed in 2008 by UGA, and the final report from that study was submitted with the 2007-08 update. Given the completion of the two prescribed studies and the additional 2008 study, we believe there are no further requirements related to this Conservation Action.

Conservation Action 3. *Georgia Power will conduct or fund six surveys in order to monitor abundance and distribution of juvenile and adult robust redhorse within Project Site.*

The fifth and sixth monitoring surveys under Conservation Action 3 are scheduled for 2010-2011 and will be conducted in conjunction with adult population surveys outlined in Conservation Action 4 and through a large-scale research study conducted by Dr. Cecil Jennings with USGS and funded by GPC. Appendix A includes the study progress report describing project activities conducted in 2010.

Conservation Action 4. *Following the establishment of an adult refugial population in the Project Site, Georgia Power will fund three surveys to measure population size utilizing the mark-recapture methods used to estimate the population size of the Oconee River robust redhorse population.*

As stated above, GPC and USGS entered into a research contract to conduct intensive monitoring surveys in the Ocmulgee River between Lloyd Shoals Dam and the East Juliette low-head dam. That study began in 2010, and preliminary results from the first year of the project are included in Appendix A.

Appendix A.

Use of hierarchical occupancy models to determine seasonal habitat use and estimate abundance on stocked robust redhorse in the upper reaches of the Ocmulgee River, Georgia

Progress Report

William A. Pruitt [1], Cecil A. Jennings [2], James T. Peterson [2,] *

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Submitted to

Georgia Power Company

7 March 2011

* Current Address: Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis, Oregon.

Introduction

A multi-stakeholder Candidate Conservation Agreement with Assurances (CCAA) was formed between Georgia Power Company, Georgia Department of Natural Resources, and the U.S. Fish and Wildlife Service and implemented in 2002. The project site covered by the CCAA includes the upper reaches of the Ocmulgee River, GA, between Lloyd Shoals Dam (A Georgia Power Company owned and operated hydropower facility impounding Jackson Lake) and a low head mill dam near Juliette, GA. The two main objectives of the CCAA are (1) to establish a refugial population of robust redhorse within the upper reaches of the Ocmulgee River, and (2) increase understanding of habitat requirements and life history of robust redhorse. Conservation actions outlined in the CCAA to achieve the above objectives include: (1) stock the project site with fingerling robust redhorse, (2) study the movement of stocked juveniles, (3) monitor abundance and distribution, and (4) estimate population size. These actions and studies to examine movements, abundance, distributions and population size of the stocked population are to continue until scientific evidence concludes that the Ocmulgee population does not need additional augmentation or monitoring (Department of Interior 2001).

To date, research within the project site has included the investigation of post-stocking habitat use and dispersal (Jennings and Shepard 2003), spawning migration and seasonal habitat use of stocked fish (Grabowski and Jennings, 2009), and the determination of robust redhorse capture probability (Grabowski et al. 2009). These studies examine conservation actions 1, 2, and a portion of 3. Our current study focuses on actions 3 and 4. The objectives of the current study include: (1) determine seasonal habitat use, (2) estimate abundance of robust redhorse, (3) determine the utility of hierarchical occupancy models for determining seasonal habitat use and estimating the abundance, and (4) provide a modeling framework that can be continuously updated or modified with data gathered during subsequent robust redhorse monitoring studies.

Detection probability for robust redhorse in the Ocmulgee River is extremely low (0.031; Grabowski et al.'s 2009). The low detection probability of a rare or elusive species is often the result of a phenomenon called imperfect detection. Imperfect detection refers to researcher's inability to detect all individuals (or species) within a study site (MacKenzie 2005). Imperfect detection often results from the rarity or cryptic nature (coloration or behavioral) of the species or the tendency of that species to inhabit areas that are difficult to sample. The use of site occupancy to determine a species' resource use is used mostly when species detection probability is very low, and such is the case for robust redhorse. Site occupancy is the determination that a species of interest inhabits a particular resource unit, and this occupancy is often some function of spatial location or various habitat characteristics that define that unit (see synthesis by MacKenzie et al., 2002; MacKenzie, 2005; MacKenzie, 2006).

Methods

All accessible portions of the project area between Lloyd Shoals Dam and Juliette Dam were sampled seasonally with standard boat electrofishing gear in accordance with survey sampling protocol outlined by the Robust Redhorse Conservation Committee (2002). The accessible portions of the project area has been stratified into 25 sample units based on mesohabitat (e.g., shoal, run, pool) and local habitat characteristics (e.g., substrate composition, local water velocity, average depth, quantity of woody debris). Each sampling unit was sampled via boat electrofishing at least twice per season for four seasons (Spring ’10, Summer ’10, Fall ’10, and Spring ’11). During each sampling occasion, data on environmental variables (e.g., water temperature, dissolved oxygen, turbidity or secchi depth, discharge) were collected and recorded. Combinations of the above variables were used as predictor variables for our occupancy models.

Each robust redhorse captured was checked for coded wire tags and Passive Integrated Transponder (PIT) tags, and implanted with a new PIT tag if one was not detected. Each captured individual’s total length (mm) and weight (g) as well as gender, breeding condition or anomalies were recorded. Additionally, other Catostomids encountered during the sampling were weight and measured; data on habitat use and habitat associations also were recorded. Occupancy data gathered from other suckers, especially those found in close association with robust redhorse, will be used in our hierarchical modeling framework. Occupancy models will be constructed using specialized computer software WinBUGS (available at http://www.mrc-bsu.cam.ac.uk/bugs/).

Preliminary Results and Discussion

During the Spring ’10 and Summer ’10 seasons, robust redhorse were detected in the first and second sampling occasions in the sample site immediately below Lloyd Shoals Dam (dates: May 10, May 24, June 30, August 3). On May 10, a spawning group of 6-8 individuals was found over shoals immediately below the dam with water being released (82 m^3/ second). This set of shoals frequently is <1ft deep during times of low water discharge (9 – 13 m^3/second) from the dam found during the summer and fall seasons. The other three detections were visual detections (e.g., fish were affected by electrofishing, but were unable to be netted), in either in the deep, fast, water of the dam's tailrace or just below the shoals adjacent to the Georgia Power boat ramp and picnic area. Robust redhorse were not detected in the Fall '10 season. Thus far, robust redhorse have not been detected in any other portions of the project site during any sampling occasions. A total of seven suckers species have been detected during the study. The numbers of captures thus far have ranged from 2029 (notchlip redhorse) and 1003 (spotted sucker) to 2 (robust redhorse, highfin carpsucker) or less (1 total captures quillback carpsucker) (Table 1). There were several individual from many species that were seen (i.e., detected), but not netted.

Seven, simple hierarchical occupancy models were constructed for the sampling seasons thus far. The models were constructed with water velocity, discharge, secchi depth, and various combinations of the three as predictor variables. Of these seven, the best-predicting model for site occupancy and calculating detection probabilities was the discharge + secchi model. Using this model, we were able to calculate the average conditional detection probabilities (the probability of detecting the species, given it is present in the sample site) for five of the most commonly encountered sucker species encountered in the 2010 sampling seasons. On average across all sampling seasons, robust redhorse detection probability was the lowest at 0.025 (Table 2). Conversely, the high average detection probabilities of notchlip redhorse and spotted suckers (0.957 and 0.981 respectively) are a direct result of the abundance and presence at nearly every sample site (Table 2).

Robust redhorse have an extremely low detection probability regardless of season (Table 2). The fall detection probability (0.012) was much lower than for spring (0.024) and summer (0.040) seasons because robust redhorse were not detected during the fall. However, the spring and summer detection probabilities are much closer to the 0.031 capture probability reported by Graboswki et al. (2009). This conditional detection probability is averaged across all sites in the project site, but is not site-specific. Robust redhorse were detected in four of six sampling occasions in the sample site below Lloyd Shoals Dam resulted. Site-specific detection probability for this site or sites exhibiting similar habitat characteristics may be much higher than our current estimates suggest.

Robust redhorse were only detected in a site that was predominantly shoal habitat, with large amounts of rocks, boulders, gravel deposits, and high water velocities, usually 0.6 – 0.8 m/second. However, only a small portion of accessible portions of the river exhibit these same characteristics. Most of these reaches, including an 8 km reach are in inaccessible and were not sampled. Approximately 1 km of the downstream end of this 8 km reach is able to be sampled, but only in times of high discharge (a minimum of 87 m^3/ second) and this value was rarely reached during our sampling occasions. This 8 km portion of the river contains abundant shoals that probably support robust redhorse. The entire project site between Lloyd Shoals Dam and Juliette dam contains approximately 19% shoal habitat. However, only ~ 3.5% of this habitat was able to be sampled during the study thus far. The project is ongoing, and plans are underway for the Spring 2011 sampling.

The Spring ’11 sampling season will commence in March and continue through the spawning period into May. Additional and more complex models will be constructed to incorporate the low detection probability. The new models will incorporate additional habitat data and their various combinations and interactions. Our intent is to find the best approximating model for determining robust redhorse site occupancy, site-specific detection probabilities, and estimate the current population status of robust redhorse.

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Table 1. Total number of suckers captured during the 2010 sampling for robust redhorse in the Ocmulgee River, GA between Lloyd Shoals Dam and Juliette Dam.

Species	Spring	Summer	Fall	Total
Quillback carpsucker *Cyprinus sp.cf. carpioides*	1	0	0	1
Highfin carpsucker *Cyprinus sp. cf. vellifer*	2	0	0	2
Spotted sucker *Minytrema melanops*	440	207	356	1003
Notchlip redhorse *Moxostoma collapsum*	623	572	834	2029
Robust redhorse *Moxostoma robustum*	2	0	0	2
Striped jumprock *Scartomyzon rupricartes*	5	4	27	36
Brassy jumprock *Scartomyzon sp. cf. lachneri*	154	63	50	267

Table 2. Average conditional detection probabilities for the five most encountered sucker species detected during the 2010 sampling of robust redhorse in the Ocmulgee River, GA between Lloyd Shoals Dam and Juliette Dam.

Species	**Spring**	**Summer**	**Fall**	**Mean**
Robust redhorse *Moxostoma robustum*	0.024	0.040	0.012	0.025
Notchlip redhorse *Moxotoma collapsum*	0.999	0.933	0.939	0.957
Spotted sucker *Minytrema melanops*	0.999	0.944	0.999	0.981
Striped jumprock *Scartomyzon rupricartes*	0.892	0.599	0.470	0.654
Brassy jumprock *Scartomyzon sp. cf. lachneri*	0.999	0.811	0.989	0.933

Appendix 3

MANAGEMENT PLAN FOR THE OCONEE RIVER ROBUST REDHORSE POPULATION

Photo courtesy of J. Evans, Georgia Department of Natural Resources

Oconee River Technical Working Group
October 2010

MANAGEMENT PLAN FOR THE OCONEE RIVER ROBUST REDHORSE POPULATION

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MANAGEMENT PLAN FOR THE OCONEE RIVER ROBUST REDHORSE POPULATION

Executive Summary

Since 1995, the Robust Redhorse Conservation Committee (RRCC) has been working to restore and conserve robust redhorse populations in their native Atlantic slope drainages in Georgia, North Carolina, and South Carolina. The RRCC was formed under a Memorandum of Understanding in 1995 and was actively renewed in 2000 and 2005. The RRCC developed a Conservation Strategy for the Robust Redhorse (Strategy), a set of Policies, a Habitat Management Plan, and other documents to promote voluntary conservation initiatives and stakeholder partnerships for conserving the species. While all RRCC members (see www.robustredhorse.com) have committed to enhancement and restoration measures for this species within its historic range, a subset have particular interest in the management of the population residing in the Oconee River, Georgia. The active members of the Oconee River Technical Working Group (ORTWG) that developed this management plan were: the U.S. Fish and Wildlife Service (USFWS); Georgia Department of Natural Resources (GADNR); Georgia Power Company (GPC); and the U. S. Geological Survey (USGS).

The ORTWG developed this plan to guide the restoration effort on the Oconee River. The plan contains a series of tasks under the broad objectives of improving knowledge of biological requirements, monitoring the status of the Oconee River population and comparing with other populations, conserving and enhancing the Oconee River population, maintaining refugial populations, and creating a schedule for revisiting this Oconee River Management Plan. The plan also describes criteria that will help the ORTWG measure success of species conservation in the Oconee River. Four goal attainment criteria will have to be met before the restoration effort can be deemed successful.

Background

The robust redhorse was briefly described by Cope (1870) from a single specimen collected in the Yadkin River, North Carolina in 1869. The historic range of the species is believed to be Atlantic Slope drainages from the Pee Dee River, North and South Carolina to the Altamaha River Basin in Georgia. The following bullets, except the last two, are taken from “A fisheries survey of the Oconee River between Sinclair Dam and Dublin, Georgia” (Evans 1994).

- The “rediscovery” of the robust redhorse in the Oconee River and subsequent recovery activities were closely linked to the Federal Energy Regulatory Commission (FERC) relicensing of GPC’s Sinclair Hydroelectric Project (FERC No. 1951) during the period 1991 – 1996. GADNR personnel conducted an investigation of fish community characteristics of the Oconee River between Sinclair Dam and Dublin in 1991 and 1992 to gather information for formulating relicensing issues. Five large, unidentified catostomids were collected during electrofishing sampling conducted on August 8, 1991, near the mouth of Commissioner Creek.
- Meristic characteristics of these specimens did not correspond precisely to any known species and average length exceeded that of all catostomid species known to occur in the Altamaha River drainage. Preserved specimens were sent to Dr. Henry Bart, then curator of the Auburn University fish collection. He indicated that the fish might belong to what

was then believed to be an undescribed species known to ichthyologists by only two existing specimens - one collected from the Savannah River, Georgia/South Carolina in 1980 and a second from the Pee Dee River, North Carolina in 1985. Informal names applied at the time to the species represented by the two Savannah/Pee Dee specimens were the bighead redhorse and the Savannah River redhorse. During the period 1981-1990, fisheries professionals in Georgia and the Carolinas had been consulted and portions of the Savannah River were sampled in an effort to obtain more specimens. None were found until the five specimens were collected in the Oconee River in 1991. Prior to this discovery, the taxonomic status of this species had been investigated by Dr. Robert Jenkins of Roanoke College in Salem, Virginia, by Dr. Noel Burkhead of the National Fisheries Research Center in Gainesville, Florida, and by Dr. Byron Freeman, Director of the Georgia Museum of Natural History. All investigators subsequently concluded that the Oconee, Savannah, and Pee Dee specimens represented a single species.

- Initially, the Oconee, Pee Dee, and Savannah specimens were believed to represent a new species, probably an Atlantic slope form of the river redhorse, *Moxostoma carinatum*. The species is now believed to have been described by master naturalist Edward Cope in 1870 from specimens collected from the Yadkin River, North Carolina and given the scientific name *Ptychostomus robustus* (*Ptychostomus* is synonymous with the present genus designation *Moxostoma*). The specimens collected from the Oconee, Pee Dee, and Savannah rivers during 1980 – 1991 represent the "rediscovery" of a species that had been lost to science for over 120 years.
- Cope's original type specimens were lost and later workers erroneously labeled specimens of other species as type specimens of robust redhorse. The scientific name *P. robustus*, which Cope had intended to be applied to the robust species represented by the Oconee, Pee Dee, and Savannah specimens, was instead misapplied by later revisionists of the Catostomidae to a smaller species. This smaller species, sympatric with the larger more robust form, has been incorrectly known in scientific literature since 1956 as *Moxostoma robustum* - the smallfin redhorse. As a result of these investigations, the scientific name *Ptychostomus* (*Moxostoma*) *robustus* will be transferred as *Moxostoma robustum* (Cope) (robust redhorse) to the species known from the Oconee, Pee Dee, and Savannah specimens. The species formerly known as the smallfin redhorse will be placed in the jumprock genus (*Scartomyzon*) and given the common name brassy jumprock (Jenkins and Freeman, in preparation; Jenkins, in preparation).
- Archaeological remains of an additional specimen from the Savannah River were discovered at the University of Georgia in the early 1990's. However, conclusive evidence of the existence of other remnant populations was not found until 1997 when Georgia Power Company personnel collected a single specimen from the upper coastal plain reach of the Savannah River about 50 river miles downstream of Augusta, Georgia.
- A remnant population of robust redhorse has since been discovered in the Ocmulgee River, Georgia and populations were found in the Savannah River, Georgia/South Carolina and the Pee Dee River, North Carolina/South Carolina.
- The species was named as a Category 2 candidate for Federal listing under the Endangered Species Act. The Category 2 designation was eliminated in 1995 and some of the species formerly with this designation were classified as "species of management concern".

1.0 Management Goals

The primary goal of this plan is to enhance and ensure a genetically diverse, self-sustaining population of robust redhorse in the Oconee River. Maintaining the sustainability of the Oconee River population would ensure that this population remains one of the six self-sustaining populations necessary to satisfy the long-terms goals of the RRCC (RRCC 2002).

2.0 Goal Attainment Criteria

The primary goal of this management plan will be realized when the following criteria are met for a self-sustaining robust redhorse population in the Oconee River:

- *Occurrence of natural recruitment to the adult population at a rate equal to or greater than the mortality rate*
- *Multiple age/size classes from natural reproduction and recruitment are present in the population*
- *Individuals can be collected in sufficient numbers to model long-term demographic trends and effective population size*
- *Augmentation with hatchery-reared individuals is not required to maintain the population of at least 400-600 adults.*
- *The long-term declining trend in population estimates and associated catch rates is reversed.*

3.0 Biology and Historic Status of Robust Redhorse in the Oconee River

Biology:

- Largest member of its genus, so far as known, as well as the largest native sucker species on the Atlantic Slope; fish attains a maximum length of approximately 31 inches and a maximum weight of almost 19 pounds (Ryan Heise, North Carolina Wildlife Resources Commission, personal communication).
- Adults have modified gill arches, which form molariform teeth. In addition to being a key diagnostic character for the species, the teeth are used to crush small mollusks (Jenkins and Freeman, in preparation). Throughout their range, their primary food source seems to be the introduced Asiatic clam (*Corbicula* sp.) (Evans 2004). Food preferences of juveniles are unknown.
- Limited age and growth studies (N = 38) conducted on fish collected from 1991-1997 revealed that the Oconee River fish that could be aged accurately ranged from 10 to 25 years of age (Jenkins et al. 1998, Roanoke College, unpublished age and growth study). Most of these fish were produced in the 1970s and early 1980s. Recruitment since the early 1990's has been low.
- Robust redhorse spawn in the spring, generally when water temperatures reach 21 - 23 degrees C (Nichols 2003). Spawning has been observed over gravel bars with moderate to swift current at depths ranging from six inches to three feet (Freeman and Freeman 2001). Females produce an average of 30,000 (range 1,700 to 86,000) eggs per season (Jaci Zelko, USFWS, personal observation).
- Spawning behavior is similar to other redhorses, wherein one female is typically flanked by two males, and the three form a spawning triad over loose gravel substrate (Freeman and Freeman 2001). The act of depositing the eggs cleanses the egg pocket of fine sediments, which has been shown to affect larval survival to emergence success. Based

on laboratory observations, fertilized eggs incubate for 3-4 days within the interstitial spaces between gravel particles (Lasier et al. 2001). Larvae remain in the gravel for an additional 7-10 days until the yolk sac is absorbed and swimup occurs (Haile McCurdy, USFWS, personal communication).

- The existing Oconee River population appears to be genetically heterogeneous and distinct from the Savannah and Pee Dee populations (Ike Wirgin, New York University, personal communication).
- Recruitment of wild individuals to the adult population appears limited. Robust redhorse reach sexual maturity at about 400 mm TL. Wild spawned juveniles (less than 400 mm TL) have not been collected in intensive sampling to date. Few (< 50) larval robust redhorse were collected in 1995 and 1996 prior to implementation of the new flow agreement (resulting from the relicensing of Sinclair Dam); larval collection has been variable (10 – 2100) after implementation (Peterson et al. 2008).
- Known harmful pathogens have not been observed from wild caught specimens. Heil (1997) examined external lesions and isolated bacteria that were opportunistic secondary invaders. Externally, there were no signs of gill, skin, or fin parasites.
- Juveniles and adults are moderately tolerant of a broad range of environmental physicochemical conditions (e.g., pH, dissolved oxygen, temperature), but in some instances a combination of factors affecting physiological and ecological requirements may act synergistically in limiting reproductive success (Walsh et al. 1998; Jaci Zelko, USFWS, personal observation).

Habitat Use and Behavior:

- In rivers with meanders, non-spawning adults are often associated with woody debris in relatively moderate to swift currents, typically in meander sections. In rivers without meanders, non-spawning adults seem to prefer deep holes, typically in association with woody debris (Jimmy Evans, GADNR, personal observation).
- Adult robust redhorse form spawning aggregates during spring, in some cases migrating long distances to spawning grounds, and then return to preferred habitat for the remainder of the year (Grabowski and Isely 2006; Ryan Heise, NCWRC, personal communication; Cecil Jennings, USGS, personal observation).
- Spawning activity in the Oconee River has been documented in only 2 – 3 small areas, generally associated with exposed gravel deposits; the first is a mid-channel gravel bar opposite the Avant Kaolin Mine (RM 120) between Toomsboro and Milledgeville; the second is a gravel bar extending from near shore to mid-channel at the lower end of a short meander section below Hwy 57 (RM 96). A third area, inferred only from the number of adults in spawning condition collected, is located near several meander bends just below the mouth of Commissioner Creek (RM 100 – 102). Specific gravel deposits associated with this aggregation have not been located. Spawning activity was also observed from 1993 to 1996 approximately 1.5 miles below the Central of Georgia railroad trestle. Spawning activity has declined gradually over a period of several years and presently the only known, active spawning site is located at the Avant Kaolin Mine. Undiscovered spawning sites may exist (Peterson et al. 2008; Jimmy Evans, GADNR, personal observation).
- In past observations, spawning aggregations have generally consisted of 30-50 adults, but more recently the number of individuals seems to have decreased. The cause for the reduction in number and/or possible shift in location of spawning aggregations over a 5 – 10 year period is unclear (Jimmy Evans, GADNR, personal observation).

- Since wild-spawned juvenile robust redhorse have never been collected from the Oconee River, preferred habitat is unknown. However, experimental studies with hatchery-reared individuals indicate that this life stage prefers areas with low to moderate current velocities (Mosley and Jennings 2007).
- Hatchery-reared juveniles released in the Ocmulgee River preferred woody debris where available; otherwise, they used boulder/cobble cover or other current refugia (e.g., bridge abutments) (Jennings and Shepard 2003, Grabowski and Jennings 2009).

Distribution:

- The historic range of the species is believed to be Atlantic Slope drainages from the Pee Dee River, North and South Carolina to the Altamaha River Basin in Georgia.
- Currently, wild populations are known to exist in the Oconee River, Georgia, Savannah River, Georgia/South Carolina, and the Pee Dee River system, South Carolina/North Carolina. Although two wild-spawned adults were collected in the Ocmulgee River in 1999, the status of the wild population there remains unclear.
- Currently, stocked populations exist in the Broad and Ogeechee rivers, Georgia, and the Broad and Wateree rivers, South Carolina (Nichols 2003; Forrest Sessions, SCDNR, personal communication). In addition, stocked individuals have been used to augment wild populations in the Oconee and Ocmulgee rivers, Georgia (Nichols 2003).

Status within Oconee River Basin:

- The Oconee River population was discovered by Jimmy Evans and Wayne Clark, GADNR, in August 1991 (Evans 1994). The species is considered to be very rare and is classified as endangered by the GADNR (GADNR 1999).
- Current range in the Oconee River is believed to be a 70-mile reach between Sinclair Dam and Dublin, Georgia. Although robust redhorse have never been collected from the immediate Sinclair Dam tailrace area or below Dublin, a telemetry study indicates that individuals are found at least intermittently below Dublin. The majority of the population appears to exist in the Fall Line Hills transition zone that extends roughly from just below the Fall Line to the beginning of the Upper Coastal Plain, or about 25 RM below Sinclair Dam to 10 RM above Dublin, a distance of about 45 RM (Jimmy Evans, GADNR, unpublished sampling data; Patrick Ely, USGS, unpublished telemetry data).
- Successful robust redhorse reproduction and recruitment is occurring in the Oconee River, but monitoring studies and results of annual broodfish sampling suggest that recruitment is relatively low (Nichols 2003).
- Annual population estimates show a population of approximately 100 adult robust redhorse in the Oconee River in 2004 (Jimmy Evans and Brent Hess, GADNR, unpublished modeling data), a decrease of approximately 75% since 1994. Long-term trends in electrofishing catch rates (Figure 1) and population estimates (Figure 2) indicate an apparent decline in the number of adult robust redhorse in the Oconee River from 1994 through 2009 (Jimmy Evans and Brent Hess, GADNR and Joey Slaughter, GPC; unpublished sampling data). The mechanism for the decline appears to have been a combination of mortality of the older age classes combined with low recruitment. Precise causes of the low recruitment are unclear. The reaches used in Figure 1 are within the broodfish sampling area (Figure 4), which is defined as the area from the mouth of Black Creek to the end of the last bend in the long meander section between Beaverdam WMA and Dublin:
    - Reach 1 is defined as the mouth of Black Creek to Central of Georgia railroad trestle;

- Reach 2 from the railroad trestle to Balls Ferry;
- Reach 3 from Balls Ferry to the Beaverdam WMA ramp;
- Reach 4 from Beaverdam Ramp to midpoint of long straight section just below Beaverdam ramp; and
- Reach 5 from the midpoint of the long straight section below Beaverdam to the end of long meander section between Beaverdam and Dublin.

- Whether the recruitment rate that has prevailed for the past decade is sufficient to sustain the population is unclear. Recent modeling results indicate that the population could be sustainable at between 30 and 400 individuals for at least several generations if current environmental conditions remain constant and population levels remain above the threshold for genetic viability (Figure 2) (Jimmy Evans and Brent Hess, GADNR, unpublished modeling data).

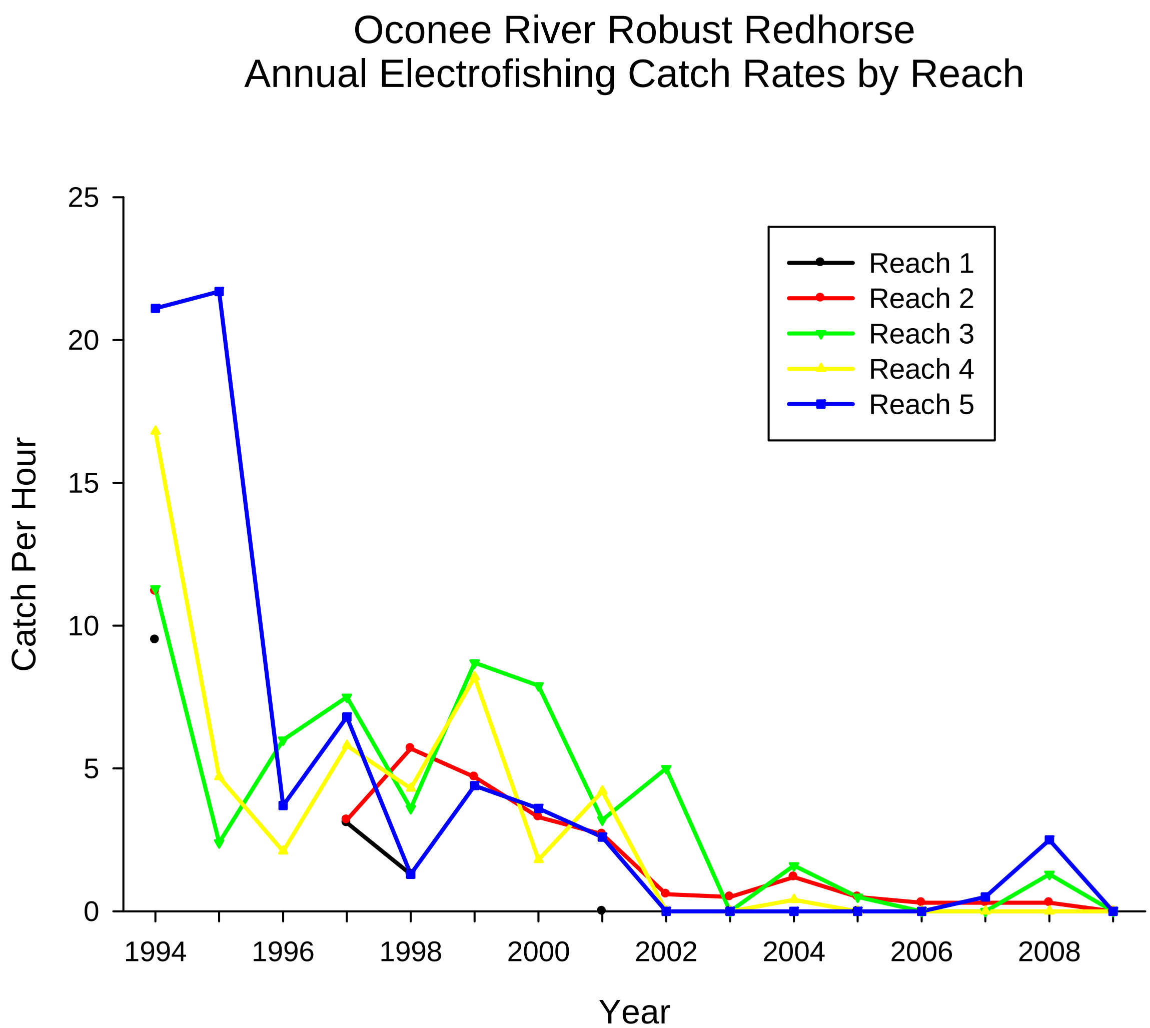

Figure 1. Electrofishing catch rates by year for robust redhorse in the Oconee River between the mouth of Black Creek and Dublin, Georgia since 1994.

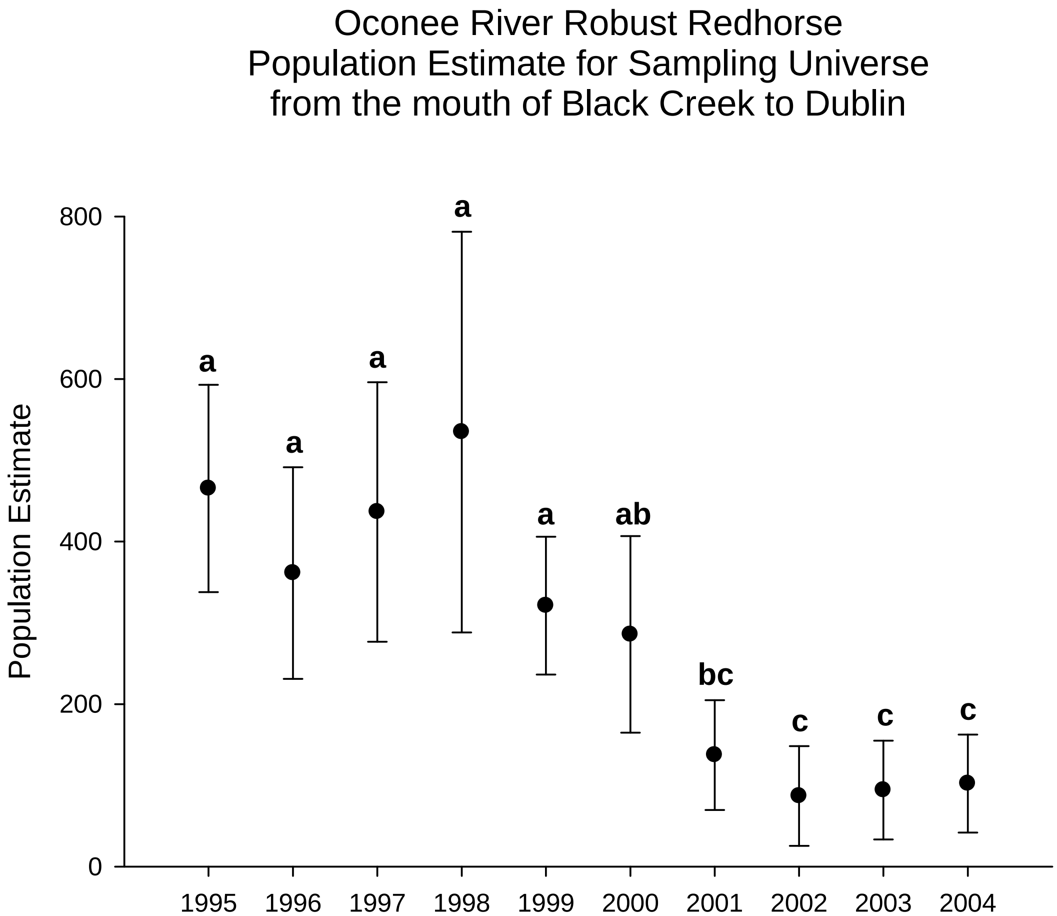

Figure 2. Mark-recapture population estimates for robust redhorse in the Oconee River between the mouth of Black Creek and Dublin, Georgia. Error bars indicate 95% confidence intervals.

Genetics:

- A target population size needs to maintain sufficient genetic variation for adaptation to environmental changes. It should be based upon the life history and genetic diversity of the organism, as well as the carrying capacity of the system (Greg Moyer, USFWS, personal communication).
- Soule (1980) and Franklin (1980) indicate a conservative effective population size of 50-500 individuals to maintain sufficient genetic variation for adaptation to environmental changes.
- Effective population size does not equal census population size. Palstra and Ruzzante (2008) found the effective population size to census size ratio to be 0.14 for a variety of organisms.
- Based on the range of initial population estimates in the Oconee River of approximately 350-600 adults, the target effective population size would be approximately 84 individuals; however, an effective population size of 50 individuals, with an appropriate sex ratio, would meet the minimum criteria for a genetically viable population.

Threats:

- Limited geographic range, low number of wild individuals, and low recruitment rates are considered the most serious threats to continued survival of the species (Bryant et al. 1996, Nichols 2003).
- Habitat alterations (e.g., sedimentation, contaminants, flow and temperature modification, barriers) that degrade or eliminate spawning or rearing habitat may limit the ability of the population to sustain itself (Nichols 2003, Lawrence et al. 2007).
- Predation and/or competition with nonnative species affect various life stages of the species. The relatively recent appearance of flathead catfish (*Pylodictus olivarus*) (Mike Geihsler, GADNR, personal communication) and blue catfish (*Ictalurus furcatus*) (Steve Schleiger, GADNR, personal communication) in the Altamaha River system pose direct predation threats or indirect threats through the alteration of predator/prey relationships**.** For example, increases in the abundance of bannerfin shiners (*Cyprinella leedsi*), known to feed heavily on robust redhorse eggs (Bud Freeman, University of Georgia, personal communication), may reflect a reduction in native predators such as redbreast sunfish (*Lepomis auritus*) caused by the appearance of flathead catfish in the Oconee River in the early 1980s.

4.0 Management Unit

The current management unit covered by this plan encompasses the Oconee River (Altamaha Basin) downstream of the Sinclair Dam in Georgia (Figure 3). If the distribution of the population is expanded beyond the current management unit boundaries, plans for those management units will be developed. The Oconee River flows through two major physiographic provinces, the Piedmont and Coastal Plain, separated by the Fall Line Hills transition zone. Robust redhorse have been stocked and recaptured in the Ocmulgee and Oconee rivers. In addition, a single individual stocked in the Oconee River was recaptured in the upper reaches of the Altamaha River. Genetic analyses indicate that the Oconee and Ocmulgee populations share numerous alleles (Wirgin et al. 2001). Currently, there are no known barriers to block movement of fish among the Altamaha, Ocmulgee below Juliette Dam, and the Oconee River below Sinclair Dam.

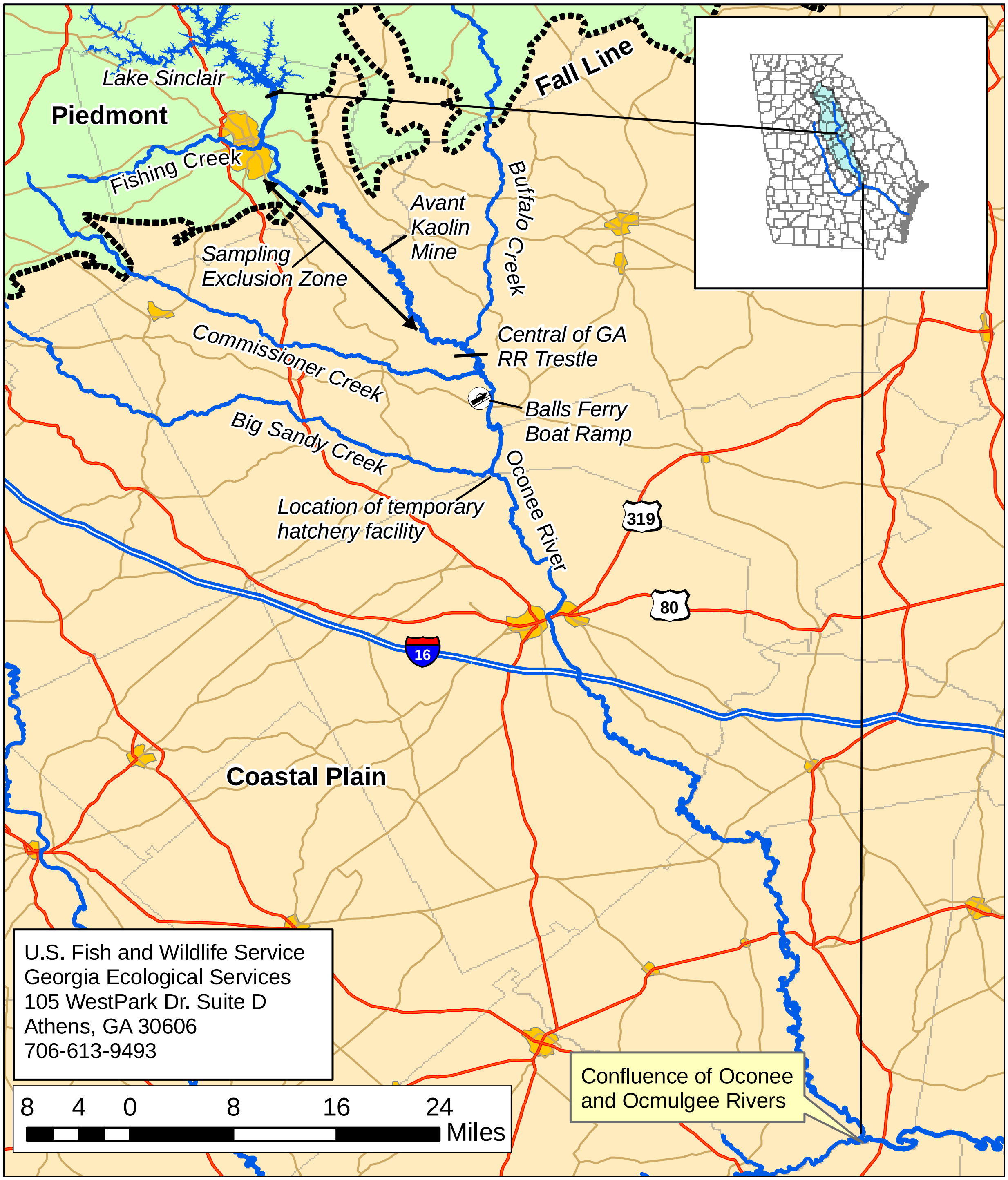

Figure 3. The portion of the Oconee River Basin covered by this Management Plan.

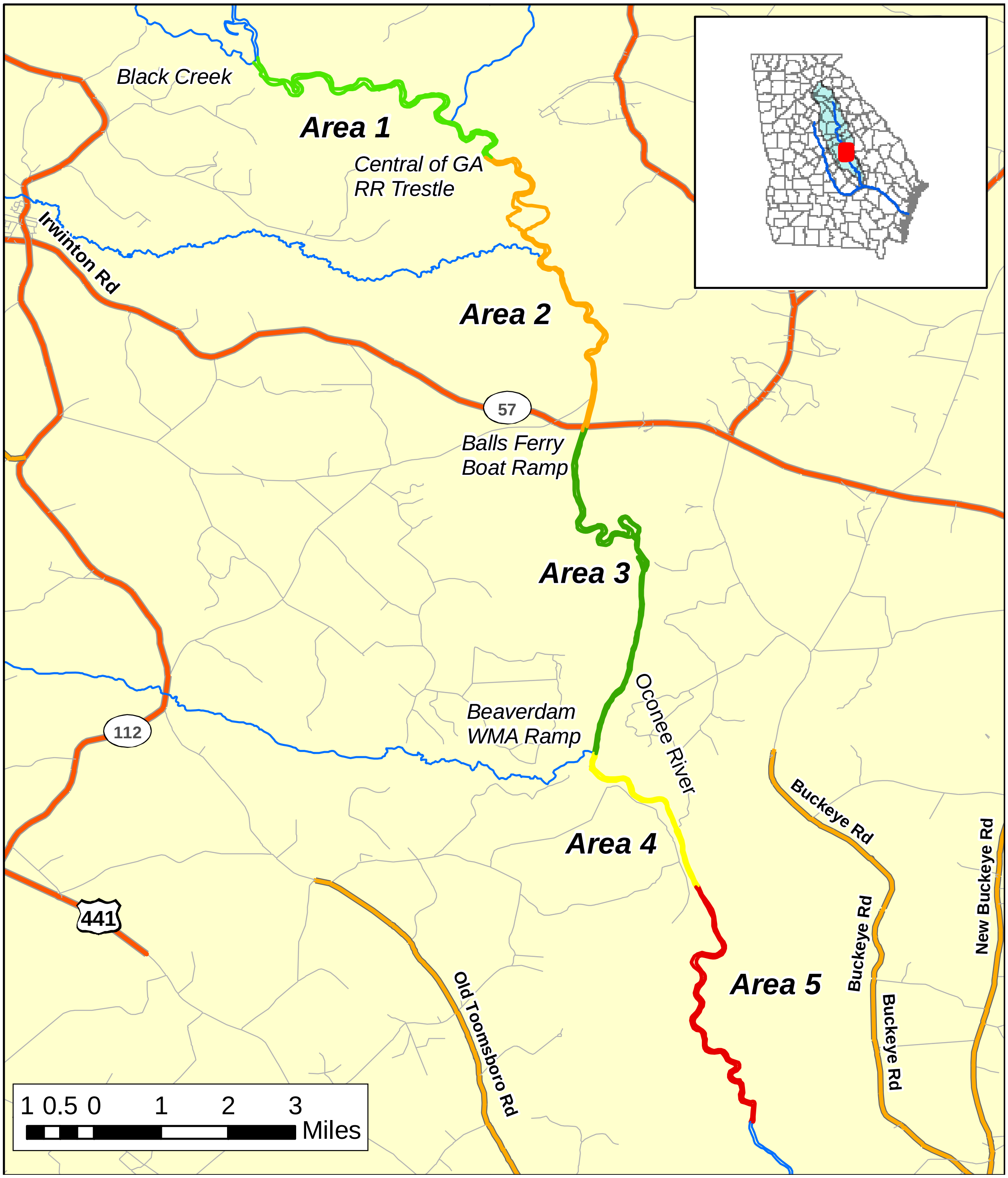

Figure 4. Delineation of sampling reaches within the broodfish sampling area.

5.0 Management History

The primary goals of the RRCC are to develop an understanding of the biology and status of this species, protect and enhance existing populations, and reestablish additional reproducing populations within its historic range. More specifically, the RRCC works to identify and prioritize data needs, evaluate project proposals for addressing those needs, coordinate conservation actions, and share information on species status.

Identification of the species and its historical range were largely completed by February 1992. Biological assessments conducted in 1992 and 1993 suggested the species has limited distribution and low abundance throughout its historical range (Jenkins and Burkhead 1993; Jenkins and Freeman, in preparation). An Oconee River population composed primarily of older individuals with extremely low recruitment rates, as evidenced by the skewed length distribution towards larger size classes, was another cause for concern (Bryant et al. 1996). Absence of individuals below about 400 mm TL may also be related to gear bias towards larger individuals. Recovery strategies were discussed at interagency meetings in September and December 1993 and the robust redhorse was classified as a Category 2 candidate for Federal listing under the ESA. Based on this information, the resource agencies agreed that flow requirements for the robust redhorse should be a major focus of the Sinclair Hydroelectric Project relicensing studies, as well as future operations affecting the downstream flow regime. Agencies also agreed that large-scale management intervention would be necessary to secure and enhance the species' status.

The 1995 Oconee River Flow Agreement for the Robust Redhorse (Agreement) was developed as part of the FERC relicensing of GPC's Sinclair Dam. Sinclair Dam modifies the flows in the section of river occupied by the Oconee River robust redhorse population. For the duration of the FERC license, the Agreement sets forth seasonally variable flow requirements that are adaptively managed for the conservation of the species (Table 1).

Table 1. Negotiated flow agreement for the 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) utilized, depending on inflow into the reservoir
[b] from June 1-10, units are operated run-of-river unless electric system demands necessitate normal peaking operation. The agreement also provides for an increase in generation (from 5 to 7 days per week) to reduce extended low-flow periods that previously resulted from little weekend generation.

Both the Agreement and the required Flow Advisory Team became important components of the new FERC license for the Sinclair Project, which became effective in 1996. A key component of the new flow regime provided higher minimum flows and enhanced flow stability, including run-of-river flows during the robust redhorse spawning season from May 1 through June 10. The new flow regime was codified in the Agreement negotiated among GPC and State and Federal natural resource agencies. The Flow Advisory Team for the Oconee River was established under a second agreement and charged with the task of monitoring the effectiveness of the new flow regime in enhancing recruitment success. Both the Agreement and the Flow Advisory Team are key elements in the current 40-year project license.

Most of our current understanding of the status of this species in the Oconee River is a direct result of relicensing studies, subsequent monitoring designed to determine the effectiveness of the negotiated flow regime in enhancing population status, and sampling conducted to collect broodfish for propagation efforts.

A robust redhorse stocking program utilizing broodfish collected from the Oconee River was conducted during 1993 - 2007. A sampling exclusion zone (Figure 3) was established above the mouth of Black Creek to avoid disturbing a known spawning site and reduce the possible harmful effects of broodfish collection on natural reproduction and recruitment.

A primary rationale for the hatchery program was the apparent low recruitment rates in the Oconee River and concerns that significant population declines were possible. Several refugial ponds were stocked and refugial populations established in the Broad, Ogeechee, and Ocmulgee rivers in Georgia. In addition, during 2000 – 2008 the wild parental population in the Oconee River was augmented with over 4,200 fingerling and juvenile robust redhorse from nine year classes. In order to avoid genetic swamping of the wild Oconee River population, relatively small numbers of larger fish produced from numerous hatchery crosses were stocked annually based on genetic evaluations. Prior to stocking, all fish received coded-wire tags and larger fish received PIT tags as well.

Management actions and research studies have been undertaken prior to the establishment of the current Oconee Management Plan. These studies were conducted in support of the broad management objectives listed below.

6.0 Historical Management Objectives:

6.1 Identify the species and its biological requirements.

6.2 Assess the status of the Oconee River population.

6.3 Identify new populations and conduct status surveys of existing populations.

6.4 Conserve and enhance the Oconee River population.

6.5 Establish refugial populations in ponds and rivers within the historic range.

6.6 Establish, maintain, and/or identify six self-sustaining populations across the historic range.

7.0 Future Management Objectives and Tasks:

Future management objectives and tasks will focus on evaluating causes of the apparent low recruitment rates and population declines that have been documented in the Oconee River over the 17-year period since the species was rediscovered. Where possible, we provide specific recommendations for improving the status of the species in the Oconee River.

7.1 Improve knowledge of biological requirements.

7.1.1 Continue to document spawning activity at known sites and identify any additional sites.

- Investigate and describe characteristics of any previously unknown spawning sites.
- Investigate any past, present and/or future sources of degradation at all sites.

7.1.2 Continue to estimate larval abundance and distribution.

- Establish trends in abundance and distribution.
- Establish relationships between observed abundance and levels required for long-term sustainability.

7.1.3 Develop non-lethal methodology for determining age of individuals.

- Investigate methodologies for scale collection, preparation, and reading, and interpretation of data collected.
- Explore feasibility of using fin-ray cross-sections as an additional method to help validate data collected from scales.
- Explore other aging methodologies.

7.1.4 Assign a year class to each collected individual.

- Age un-tagged fish by non-lethal methods (e.g., scales, rays).
- Age tagged fish by determining a coded-wire tag location or PIT tag number.

7.1.5 Determine an appropriate length frequency distribution for a self-sustaining robust redhorse population.

- Compare Oconee River histograms developed in recent years when sample sizes were relatively low to earlier years when sample sizes were larger.
- Assess contributions of stocked fish to histogram.
- Determine if recent histograms suggest sustainability without stock augmentation.
- Compare histograms collected from robust redhorse in the Oconee River with catostomids collected from other rivers.
- Compare histograms of robust redhorse collected from the Oconee River with histograms collected from other robust redhorse populations.

7.1.6 Continue to investigate seasonal movement/migration patterns and habitat preferences through radio-telemetry studies, as appropriate.

- Conduct targeted electrofishing sampling to verify the presence of wild-spawned fish in association with locations of radio-tagged fish.
- Characterize population demographics and habitat preferences of any previously undiscovered aggregations of wild-spawned fish.

- Factor these observations into assessments of species status in the Oconee River.

7.2 Monitor the status of the Oconee River population and compare with other populations.

7.2.1 Continue observations and assessment of spawning activity at known spawning sites.

- Standardize methods of observation and reporting requirements.

7.2.2 Continue and refine standardized electrofishing program.

- Standardize sampling variables to conditions that have been maintained during broodfish sampling conducted from 1994 to present.
- Continue to evaluate long-term trends in the status of the Oconee River population.
- Develop additional statistical methods as needed to analyze trend data.

7.2.3 Survey areas not specifically targeted in the past, sampled only sporadically, or outside the management unit. These areas include:

- Sinclair Dam tailrace area to Hwy 22 in Milledgeville;
- Dublin to the confluence with the Ocmulgee River;
- Lake Oconee to Barnett Shoals Dam; and
- Oconee River above Barnett Shoals and Middle and North Forks in the Athens area.

7.2.4 Monitor reproductive output by continuing larval and juvenile sampling.

- Focus on habitat types and seasons that have not been sampled extensively in the past, including using information gathered from surveys in other river systems.
- Develop consistent sampling strategies and technologies to collect larvae and juveniles.

7.2.5 Develop a consistent population estimate methodology.

- Conduct population modeling using more recent sampling data.
- Evaluate applicability and conduct population modeling using a variety of appropriate models.
- Compare modeling results and interpretations.

7.2.6 Evaluate effectiveness of various sampling methodologies and gear types.

- Test gears and techniques used for catostomid sampling in other river systems.
- Evaluate these gears and techniques for sampling robust redhorse.
- Modify sampling protocols as needed to develop more efficient sampling regimes.

7.2.7 Review existing data on habitat quality and quantity to develop a more accurate estimate of available habitat.

- Repeat flow/habitat and low-velocity cell modeling using more recent information on habitat preferences of various life stages.
- Update the 1994 gravel survey conducted in the Oconee River with current data and develop a long-term monitoring strategy.
- Compare early aerial photos, maps, etc. with more recent images from Google Earth to assess changes in channel morphology.
- Relate any changes to possible large-scale habitat modifications that may affect robust redhorse habitat availability and quality.
- Determine if current flow regime provides optimal habitat for critical life stages. Provide appropriate flows as needed.
- Determine data needs and evaluate relationships between long-term changes in temperatures in the project area and declines in reproductive and recruitment success.
- Determine data needs and evaluate relationships between observed water quality and reduced reproduction and recruitment success.

7.2.8 Update information regarding habitat use based on results of periodic habitat surveys in the management unit.

- Evaluate preliminary observations of robust redhorse spawning over gravel deposits in deeper areas.
- Assess the quantity of suitable and available spawning, larval, and juvenile habitat.

7.2.9 Evaluate the contribution of stocked fish to the adult population.

- Incorporate the stocked component of the population into modeling exercises.
- Determine relative contribution of stocked fish under various levels of recruitment into the models.
- Evaluate the need for additional stocking to achieve population sustainability.
- Determine overall contribution of stocked fish to long-term genetic sustainability of the Oconee population.

7.3 Conserve and enhance the Oconee River population.

7.3.1 Quantify the effects of predation on robust redhorse survival.

- Determine the significance of flathead catfish or other predation pressures which may limit recruitment, such as through literature review, workshops, and/or field studies.
- Make decisions on predator abatement strategies, if needed.

7.3.2 Actively participate in the environmental review process, as appropriate.

- Evaluate potential effects of development projects on the Oconee River robust redhorse population.

- Focus on possible effects of flow quantity and quality, including sedimentation and temperature alterations that could affect all life stages of robust redhorse.

7.3.3 Continue evaluation of habitat augmentation and identify augmentation strategies to address habitat bottlenecks.

- Continue evaluation of gravel augmentation projects, to include the magnitude and characteristics of gravel transport from the project area, levels and rate of sedimentation, and seasonal utilization by robust redhorse.
- Modify future projects based on results of monitoring.
- Develop additional augmentation strategies, if needed (e.g., large woody debris, bank stabilization).
- Locate funding sources for additional projects if effectiveness is demonstrated.

7.3.4 Continue efforts to maximize genetic diversity.

- Determine genetic characteristics of stocked population and genetic diversity in the wild spawned component.
- Develop appropriate strategy to enhance genetic diversity if required.

7.3.5 Continue to refine artificial propagation and culture methods (e.g., pond rearing, cryopreservation).

- Develop protocols for appropriate use of cryopreserved sperm in artificial propagation.
- Evaluate intensive culture success of fry and fingerlings at various hatcheries.

7.3.6 Determine need and methodology for additional supplemental stocking(s) in the Oconee River.

- Determine characteristics of stocked population (age/year class distribution, genetic diversity).
- Conduct population monitoring under assumption of no recruitment from stocked fish as well as various levels of recruitment.
- Assess population sustainability/risk of extinction of Oconee population with no additional augmentation and at various levels of future augmentation.
- Factor genetic risks from inbreeding depression, outbreeding depression, and genetic swamping into assessments of the need for future stocking.
- Determine most appropriate sizes, ages, and sources of juveniles for future stocking, if needed.

7.3.7 Quantify the effects of angler harvest on robust redhorse survival.

- Conduct a targeted creel survey or develop an angler questionnaire.
- Incorporate harvest estimates into population models.

- Publicize harvest restrictions for robust redhorse to minimize potential harvest.

7.3.8 Expand public education and outreach efforts.

- Place signage at major access points that describes the recovery efforts, aids in species identification, lists possible threats, explains ways that the public can assist, and encourages the release of all robust redhorse that may be caught by anglers.
- Develop press releases and other educational materials in coordination with public relations offices of the GADNR, GPC, UGA, and FWS.
- Encourage ownership and participation in the recovery project by the public within the project area.
- Update the RRCC, FWS, and GADNR websites with new developments, information, press releases, etc.

7.4 Maintain refugial populations.

7.4.1 Monitor refugial populations and augment as needed.

- Conduct studies of stocked refugial populations in the Ocmulgee, Ogeechee, and Broad rivers to determine population size and demographics, movement patterns, habitat use, reproductive and recruitment success, and genetic composition.
- Determine if stocked populations are sustainable and if additional stock enhancement is needed.

7.4.2 Evaluate the need for establishing additional refugial populations.

- Evaluate habitat suitability throughout the Oconee River Basin, especially from Lake Oconee to Barnett Shoals and from Barnett Shoals to above Athens.
- Conduct targeted sampling to ensure robust redhorse do not exist in these areas.
- Determine the most appropriate strategy for introducing fish into the area if suitable habitat is available and robust redhorse are not detected.
- Monitor refugial population dynamics, predator-prey interactions, habitat use, and threats within refugial populations.

7.5 Create a schedule for revisiting this Oconee Management Plan.

7.5.1 Objectives and action items outlined in this report suggest a planning horizon of about 10 years.

- Annual progress updates will be prepared for the RRCC.
- Revisions to the management plan will take place every five years.
- Long-term objectives will be readdressed every ten years.

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