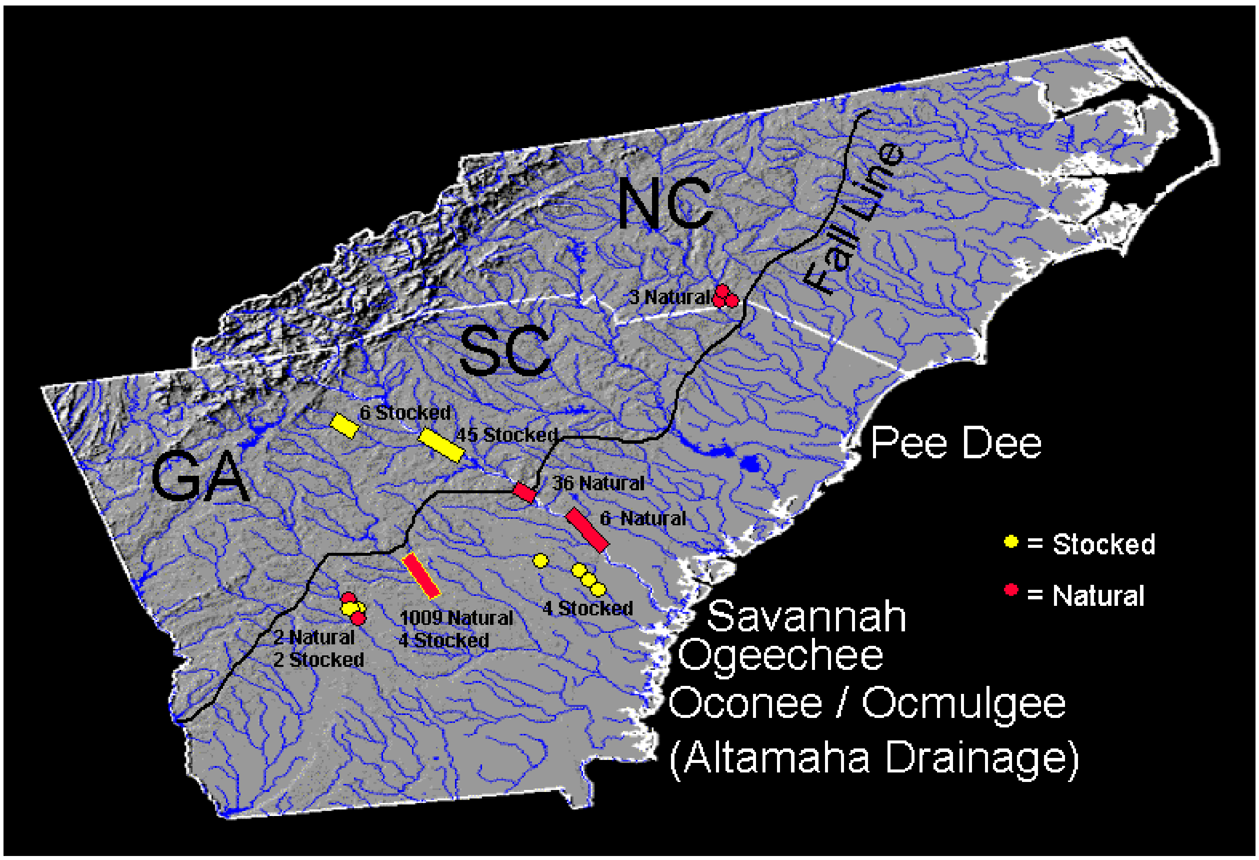
REPORT OF THE

ROBUST REDHORSE CONSERVATION COMMITTEE ANNUAL MEETING

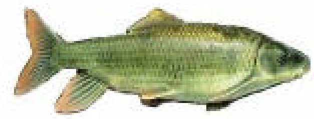
SOUTH CAROLINA AQUARIUM, CHARLESTON
OCTOBER 3 – 5, 2001



With the increased emphasis on status surveys, the number of verified records throughout the historic range has increased dramatically and many of the recent records are stocked fish (map created by Jimmy Evans, GA DNR).

Meeting facilitated by Jim Feldt, Consensus Builders
under contract with the United States Fish and Wildlife Service
Report compiled by T.A. DeMeo

T A B L E   O F   C O N T E N T S



T A B L E O F C O N T E N T S

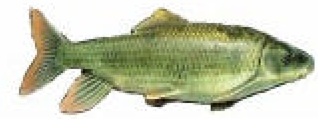
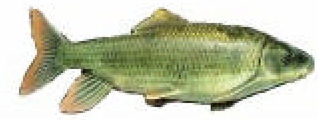


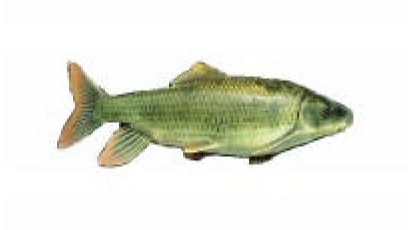
TABLE OF CONTENTS



TABLES

ATTACHMENTS

ACRONYMS & ABBREVIATIONS



CGBS	Central Georgia Branch Station, UGA
CP&L	Carolina Power and Light Company
DPC	Duke Power Company
DWC	Dennis Wildlife Center
FERC	Federal Energy Regulatory Commission
GA DNR	Georgia Department of Natural Resources
GPC	Georgia Power Company
GRN	Georgia Rivers Network
GWF	Georgia Wildlife Federation
NC WRC	North Carolina Wildlife Resources Commission
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resource Conservation Service
NYU	Institute of Environmental Medicine, New York University School of Medicine
PNWR	Piedmont National Wildlife Refuge
PSU	Pennsylvania State University
RC	Roanoke College
SC DNR	South Carolina Department of Natural Resources
SCA	South Carolina Aquarium
UGA	University of Georgia
USACOE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey (Biological Resources Division)

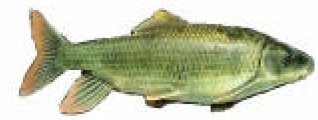
FTC	Fish Technology Center
NFH	National Fish Hatchery
SFH	State Fish Hatchery
WMA	Wildlife Management Area

MOU	Memorandum of Understanding
RRCC	Robust Redhorse Conservation Committee
CCAA	Consolidated Conservation Agreement with Assurances for the Ocmulgee River

C	Celcius
cfs	Cubic feet per second
cm	Centimeter
g	Gram
kg	Kilogram
m	Meter
mg/l	Milligrams per liter
m^3/s	Cubic meter per second
mm	Millimeter
NTU	Nephelometric Turbidity Unit
ppt	Parts per thousand
rkm	River kilometer
RM	River mile
TL	Total length
yc	Year class
YOY	Young of year

AGR	Artificial genetic refuge
Ca	Calcium
CPB	Captive production broodstock
DB	Database of Captures 1992 – 2001
DMSO	Dimethyl sulfoxide
GHRM	Genetics hazard and risk management
GCU	Genetics conservation unit
HBSS	Hanks' Balanced Salt Solution
Mn	Manganese
MtDNA	Mitochondrial DNA
nDNA	Nuclear DNA
N*e*	Effective population size
PCR	Polymerase chain reaction
Sr	Strontium

E X E C U T I V E S U M M A R Y



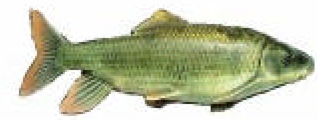
The robust redhorse recovery effort, in its 7th year, encompasses management activities and research and conservation efforts undertaken by members of the Robust Redhorse Conservation Committee (RRCC), university scientists, and other affiliates. The RRCC, established by a Memorandum of Understanding (MOU) signed in 1995, is responsible for developing and managing a recovery approach for the imperiled robust redhorse (*Moxostoma robustum*). The effort and expertise applied to the questions of recovery are brought together at the annual meeting of the RRCC. This report summarizes updates on management activities, research findings, and conservation efforts and documents decisions made at the 2001 RRCC Annual Meeting. Below are highlights of the meeting held October 3 – 5, 2001 at the South Carolina Aquarium in Charleston, South Carolina.

The RRCC was fortunate to have Tim Modde and Holt Williamson share their knowledge and expertise on restoring fish species through work with the razorback sucker in the Upper Colorado River Basin. Mr. Modde spoke on the overall approach to restore the razorback sucker, while Mr. Williamson focused on management of the species' genetics and captive propagation program. In learning of the razorback sucker effort, it became apparent that the RRCC is tackling similar issues as much larger and better-financed recovery programs, that its management decisions are within the realm of broadly acceptable practices, and that its work and accomplishments are to be commended given the resources and voluntary nature of the partnership.

In 2001, there was a continued emphasis on robust redhorse status surveys in selected rivers in the historic range. Intensive surveys were undertaken in the Pee Dee River in North Carolina and South Carolina, the Broad River in South Carolina and the lower Ocmulgee River of Georgia. While one robust redhorse was captured from the Pee Dee River, none were detected in the either the Broad River or the lower Ocmulgee River. The Pee Dee River surveys are informing Carolina Power & Light's documentation for FERC re-licensing. The Broad River surveys are supporting a plan to re-establish a self-sustaining population of robust redhorse in South Carolina, which the RRCC supports. The Ocmulgee River surveys support the implementation of a Consolidated Conservation Agreement with Assurances (CCAA) for a portion of the river that also involves the re-introduction of robust redhorse and other management activities. The CCAA is under final review and could appear in the Federal Register in a few weeks. If signed, the CCAA would be the second such agreement in the nation and the first undertaken for an aquatic species. Due to the increased activities in North Carolina and South Carolina, a Carolina Technical Advisory Group (TAG) was established to guide efforts under the direction of the RRCC.

At each annual meeting, the RRCC must reach concurrence on research results and implications; agree on the evaluation of the pros and cons of management options; and seek consensus on goals, management decisions, administrative procedures, and other matters. The RRCC and the robust redhorse recovery effort have matured to a point where it is beneficial for the RRCC to evaluate its structure and function and its goals for each river basin and management action. Therefore, the RRCC agreed to establish a set of policies to guide these matters and asked the Georgia TAG to oversee its development for review and approval at the 2002 annual meeting.

INTRODUCTION



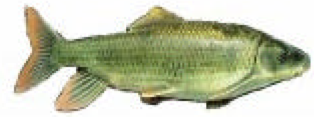
Historically, the robust redhorse inhabited Atlantic slope drainages from the Pee Dee River system in North Carolina to the Altamaha River system in Georgia. The first scientifically confirmed sighting of robust redhorse since naturalist Edward Cope described the species in 1869 occurred when the fish was re-discovered in the Oconee River in Georgia in 1991. The species is presently known to exist in a relatively short reach of the Oconee River between Sinclair Dam and Dublin, Georgia and in a short upper Coastal Plain section of the Ocmulgee River in Georgia. Individuals also have been found in the Savannah River (the boundary river between Georgia and South Carolina) in the Augusta Shoals area as well as below the New Savannah River Bluff Lock and Dam. In addition, two specimens have been captured in the Pee Dee River below Blewett's Falls Dam in North Carolina. The robust redhorse appears to inhabit specialized areas of large rivers, which are difficult to sample but regardless of the absence of sightings, small numbers are usually found when species-targeted surveys are conducted.

River impoundments, predation by introduced nonnative species, and significant deterioration of habitat due to sedimentation and water pollution are believed to have contributed to the decline of the species. The complex and diverse problems facing the robust redhorse require an interdisciplinary approach, using a broad spectrum of experience, expertise, and management authority to maintain and restore this imperiled species. In addition, it is essential that recovery efforts include a process that works closely with the private sector as well as government agencies potentially impacted by and interested in robust redhorse conservation.

The Robust Redhorse Conservation Committee (RRCC) was established by a MOU signed in 1995 to develop and manage a recovery approach for the robust redhorse (*Moxostoma robustum*), previously a Category 2 candidate for Federal listing under the Endangered Species Act. The RRCC is actively committed to the recovery of the imperiled robust redhorse throughout its former range. It identifies priority conservation needs for the robust redhorse and its habitat and coordinates implementation of research and management programs for addressing those needs.

The annual RRCC meeting satisfies partial requirement for conservation of the species as designated in the MOU. It also represents the only scheduled time for all interests to assess progress and to establish management directions that guide recovery efforts in the upcoming year and beyond. The annual meeting is the occasion to explore the scientific and management implication of research results and new data, to debate philosophical viewpoints, and to gather the collective expertise of fisheries and environmental management professionals. This dialogue includes the best available science on the robust redhorse, which forms the basis of the RRCC's recovery and policy decisions.

The seventh annual meeting of the RRCC was held October 3 - 5, 2001 at the South Carolina Aquarium in Charleston. Approximately 44 representatives of the signatory agencies to the MOU, university research affiliates, and other interests attended the meeting (Attachment 1). The 14 signatory agencies include: Georgia Department of Natural Resources, South Carolina Department of Natural Resources, North Carolina Wildlife Resources Commission, Georgia Power Company, Carolina Power and Light Company, Duke Power Company, South Carolina Electric and Gas Company, U.S. Fish and Wildlife Service, U.S. Geological Survey (Biological



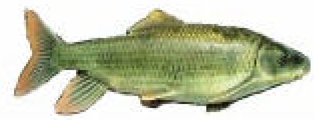
Resources Division), U.S. Forest Service, U.S. Army Corps of Engineers, Georgia Wildlife Federation, Georgia Rivers Network, and South Carolina Aquarium. University research affiliates include: University of Georgia Warnell School of Forest Resources, University of Georgia Institute of Ecology, University of Georgia Cooperative Fish and Wildlife Research Unit, University of Georgia Department of Geology, University of Georgia Carl Vinson Institute of Government, University of Georgia Department of Genetics, Clemson University Cooperative Fish and Wildlife Research Unit, New York University School of Medicine Institute of Environmental Medicine, Roanoke College Department of Biology, and Pennsylvania State University Biology Department. In addition, representatives of other concerns with interest in recovery of the robust redhorse include the North Carolina State Museum of Natural Sciences and Santee Cooper Power Company. The success of the recovery effort, to a large extent, depends on the willingness of RRCC members and others to participate in the annual meeting and to continue to support recovery throughout the year.

The 2001 annual meeting was the first held outside of Georgia and also the first time the meeting included scheduled evening events. These events were provided to enhance networking opportunities among the folks from three states who have an interest in the robust redhorse recovery effort. During one evening, Dr. Jenkins presented his full-length video titled, *Chronology, Habitat and Behavior of Spawning of Redhorse Suckers, Genus Moxostoma*. Another first for the RRCC annual meeting was the participation of scientists and research managers involved in the recovery of the razorback sucker in the Upper Colorado River Basin (summaries of their presentations are contained in this report). The RRCC was fortunate to have the opportunity to hear of other fish restoration efforts and learn that the robust redhorse recovery issues are not unique and that its management strategies are similar to those instituted elsewhere.

This report summarizes updates on management activities, research findings, and conservation efforts and decisions made at the 2001 RRCC Annual Meeting. The RRCC Annual Meeting Reports have become important documents of research, science, management, and recovery that are often referred to and cited. The format of this year's report has changed to provide a more accurate record of activities. The 2001 Annual Meeting Report relied on each presenter to provide a written summary of the updates presented at the annual meeting. As a result, the report is longer and more detailed than in previous years and in some cases, the summaries are near to journal publication quality. In a few instances, the report notes that presentation summaries were not submitted but includes discussion points and/or notes recorded by the meeting facilitator and participants. When presentations elicited questions, the main ideas were captured by the meeting facilitator and are presented at the end of the summary under the subheading, Discussion Points.

The RRCC identifies and prioritizes work items during the annual meeting. The following work items (in italics) were identified at the 2000 annual meeting and completed during 2001.

1. *Support a search for a USFWS trainee to coordinate and continue the spring spawning operations.*
   The RRCC submitted a letter to the USFWS documenting the importance of the broodfish collection and cyropreservation research to the robust redhorse recovery effort. The



correspondence was followed by a meeting with the assistant regional director for fisheries to support the search for a timely and knowledgeable replacement. Although the agency expressed its intent to fill the position, once vacant, no solid commitment for a trainee was made.

2. *Develop a protocol for the prevention, control, and management of diseases in hatcheries.*
   Protocols for the culture, broodfish collection, and disease of robust redhorse were developed and distributed at the meeting; additional copies are available upon request.

   Other reports distributed at the meeting include: *Contaminant Impacts to Early Life Stages of the Robust Redhorse (Moxostoma robustum) in the Lower Oconee River*, by Peter Lasier and *Piedmont National Wildlife Refuge Management Study*, by Jay Shelton. Both reports are available upon request.

3. *Complete and distribute the video*.
   The *Robust Redhorse: The Mystery Fish* video was completed and 140 copies distributed. A full summary of this activity is provided in the Announcements section of this report.

4. *Convene a nominating committee to nominate a Vice Chair*.
   The Nominating Committee selected and the RRCC approved Greg Looney as Vice Chair to assist the current Chair for one year and then assume the Chair position at the conclusion of the 2002 annual meeting.

5. *Conduct status surveys per the established priorities.*
   Status surveys in all three states increased in frequency and intensity. The results of surveys in Georgia, North Carolina, and South Carolina are reported in full in the Status Surveys section of this report.

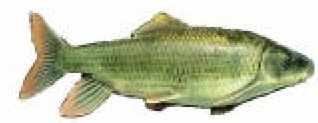
6. *Pursue installation and display of robust redhorse at the South Carolina Aquarium in Charleston*.
   Robust redhorse were installed in the Piedmont River Exhibit at the Aquarium; a full summary of this and other robust redhorse activities at the Aquarium are provided below.

Progress was made on the following 2000 work items but they remained largely unfinished at the time of the 2001 meeting.

7. *Bring the Robust Redhorse Web page online.*
   The web page is online but requires more narrative describing the RRCC and the recovery effort as well as more complete documentation of reports. This remains a priority for 2002.

8. *Explore the possibility of establishing a RRCC coordinator position*.
   Not much progress was made as fiscal resources are becoming more limited.

I N T R O D U C T I O N



The 2002 RRCC Annual Meeting will be held at a site in South Carolina either October 16 to 18, 2002 (first choice) or October 9 to 11, 2002. Participants agreed to expand the meeting to two and one-half days to schedule more time for discussions and decisions. For the same reason, they also requested that (1) routine information be distributed with the agenda prior to the meeting, (2) the TAG set priorities on issues to be addressed by the RRCC, and (3) presenters email their presentations prior to the meeting so that they can be loaded into one computer for projecting.

Opening Remarks

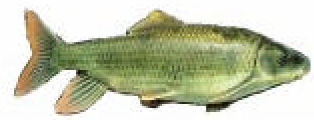
Ms. DeMeo, RRCC chairperson, opened the 2001 annual meeting by welcoming everyone and thanking sponsors: the Coca-Cola Company, CH^{2}M Hill, and South Carolina Electric and Gas Company for refreshments; the South Carolina Aquarium for providing meeting accommodations; and the South Carolina Department of Natural Resources, Fisheries for coordinating much of the meeting logistics and making available the Marine Resources Center on James Island. Ms. DeMeo recognized the South Carolina Aquarium and South Carolina Electric and Gas Company as two new signatories to the Memorandum of Understanding (MOU) that frames the robust redhorse recovery effort and distributed revised versions of the MOU. She introduced the meeting facilitator, Dr. Jim Feldt, who explained his role, set some ground rules for the session, and conducted introductions of the participants.

South Carolina Aquarium Robust Redhorse Exhibit and Educational Efforts – Chris Andrews, David Wilkins, and Whit McMillan, SCA

Dr. Andrews, Executive Director, welcomed participants to the South Carolina Aquarium (SCA). He noted that the robust redhorse recovery effort is precisely the sort of conservation project with which aquariums and zoos need to be involved. He pointed out that the public sees zoos and aquariums as trusted messengers and that the SCA is excited to assist the RRCC in this manner.

Mr. Wilkins, Freshwater Aquarist, described the installation of robust redhorse in the Piedmont River exhibit. Eight fish were installed in May 2001 and had been doing very well. One fish was lost early and 1 had just died due to a tapeworm parasite; 6 now remain. The SCA hopes to display more robust redhorse in an enlarged, reconstructed Piedmont River tank.

Mr. McMillan, Conservation Education Manager, discussed SCA's specific public education programs including display placards, volunteer docents that conduct school and other group tours, and structured topical programs onsite and in the field. As a further example of SCA's important education role, its publicity monitoring effort reported that 21 national television stations ran news stories on the SCA exhibit of robust redhorse and the recovery effort during June and July 2001. In addition, 11 print media stories appeared in southeastern newspapers during that same time.

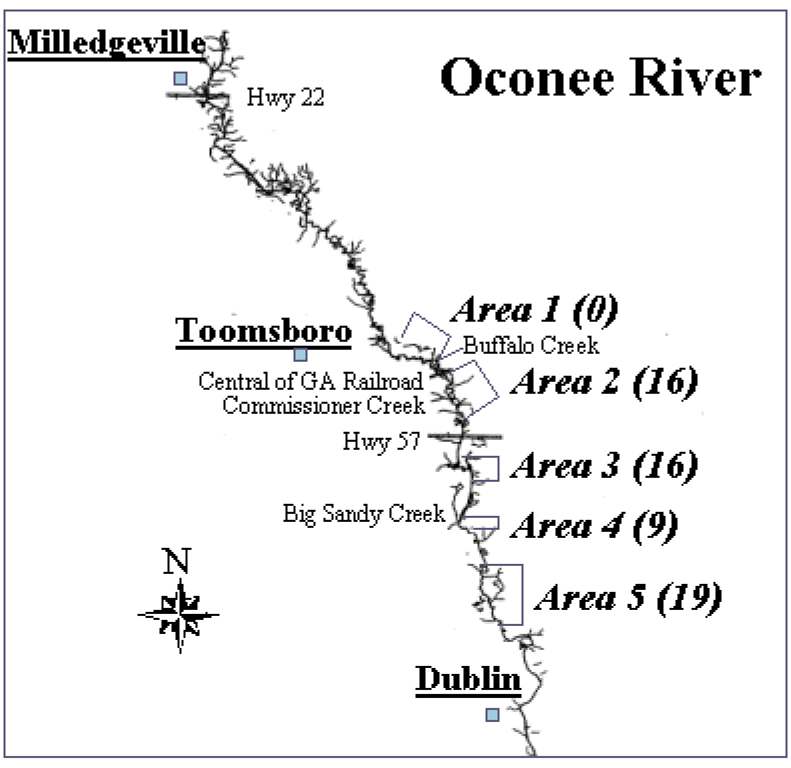


Broodfish Collection on the Oconee River, 2001 – Jimmy Evans, GA DNR

Broodfish were collected from the Oconee River between Toomsboro and Dublin, Georgia on 23 April – 21 May 2001 to provide broodfish for hatchery production of robust redhorse fingerlings. Nine females (20%), 35 males (76%), and 2 immature fish (4%) were collected by electrofishing (total of 46 individual fish). Twelve fish were captured two or more times. The low number of females collected was attributed to abnormal temperature fluctuations during April, which may have disrupted egg maturation and interfered with the onset of typical spawning behavior. Since broodfish are normally collected in spawning aggregations, reduced spawning activity may result in lower electrofishing catch rates, especially for females.

A total of 35 broodfish (76%) were recaptures of previously tagged fish. Three of the recaptures were larger juveniles that had been stocked into the Oconee River between Milledgeville and Dublin in 2000 and 2001. One wild spawned juvenile was also collected in 2001. The overall electrofishing catch rate was 2.8 fish per hour, the lowest annual broodfish capture rate to date. As in previous years, 5 known spawning aggregations were sampled (Figure 1). These areas constitute approximately 60% of the known potential spawning habitat on the Oconee River. No fish were collected in Area 1, 16 from Area 2, 16 from Area 3, 9 from Area 4, and 19 from Area 5.

Figure 1. Spawning aggregations on the Oconee River.



The modal length of the length frequency distribution of captured broodfish in 2001 was 66 cm. An apparent shift toward larger fish is noted when comparing length distributions in 1994 and 2001 (Figure 2). This may indicate an aging of the population during this 8-year period. A

general shift toward older, larger fish is also noted when comparing annual length distributions for each year during the 1994 – 2001 period (Figure 3). Size structure of the population has remained relatively constant, however, for the last several years.

Figure 2. Length distributions, 1994 – 2001.

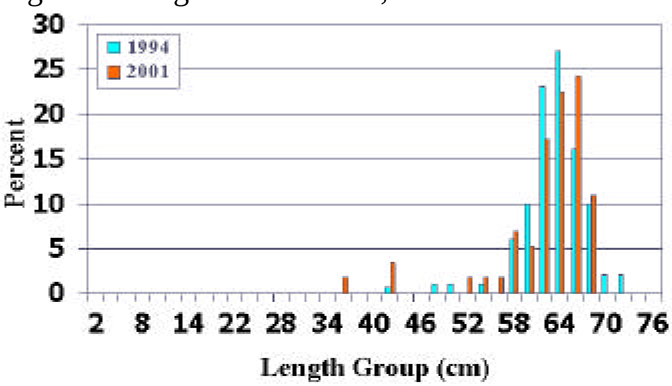
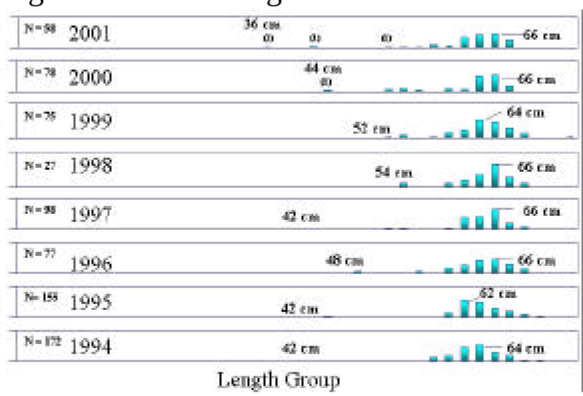


Figure 3. Annual length distributions.



Increased recruitment of young fish into the population was apparent in 2000 and 2001 (Figure 3), the result of a combination of natural recruitment and the entry of stocked fish into the population. A total of 92 juveniles were stocked in 2000 and an additional 85 prior to sampling in 2001. The stocked fish were distributed among 4 sites between Milledgeville and Dublin. One stocked fish (44 cm) was collected in 2000 and three (36, 42, 51 cm) in 2001. The increased recruitment level was reflected in a reduction in the mean length of the sampled population in 2000 and 2001 (Figure 4).

The 2001 electrofishing catch rate of 2.8 fish per hour was the lowest on record for broodfish sampling on the Oconee River (Figure 5). The highest catch rates were 19.7 and 16.5 fish per hour in 1994 and 1995. The catch rate declined dramatically to 7.8 fish per hour in 1996 and declined still further during the 1997 – 2001 period (6.1 – 2.8 fish per hour). Analysis of variance indicated that the 1994 and 1995 catch rates were significantly higher than those for 1997 – 2001 and that 1996 represented a transition year between the periods of higher and lower catch rates. Although the lowest on record, the 2001 catch rate of 2.8 fish per hour was not significantly lower than those for 1997 – 2000.

Figure 4. Mean lengths, 1992 – 2001.

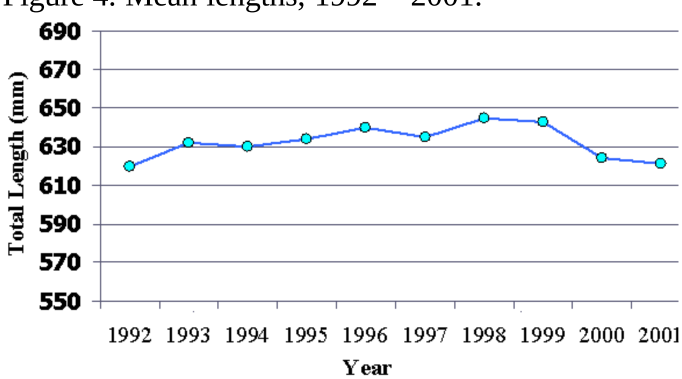
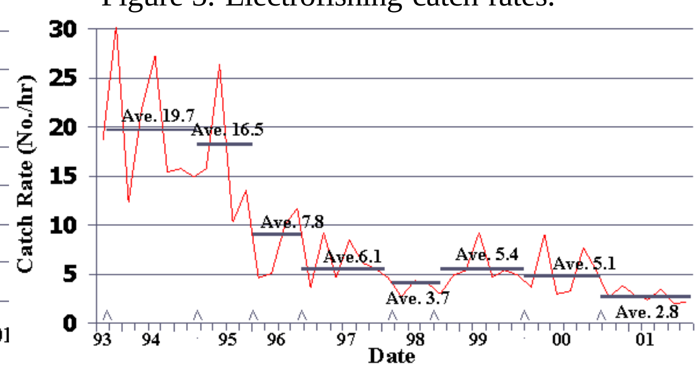
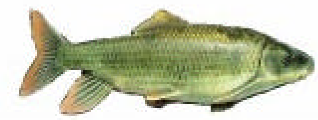


Figure 5. Electrofishing catch rates.



S U P P L E M E N T A L B R E E D I N G



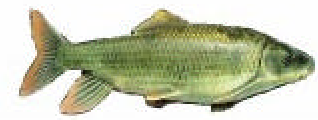
The Oconee River was first stocked with juvenile robust redhorse in February 2000. All juveniles were produced from Oconee River broodfish and were stocked according to guidelines established by the RRCC. These guidelines limited the number of stocked fish to a maximum of 100 in any year and required that the stockings have associated research objectives. Stocking is to be reevaluated each year by the RRCC and modified or eliminated based on results of previous stockings and evolving objectives.

A total of 92 robust redhorse juveniles were stocked into the Oconee River at Hardwick, Balls Ferry, and the Beaverdam Wildlife Management Area (WMA) on 23 February 2000 (Table 1). Thirty-six were from the 1995-year class (yc), 54 from the 1997 yc, and 2 from the 1998 yc. Lengths varied from 268 to 362 mm and weights from 225 to 615 g. In addition, 85 juveniles from the 1995, 1997, 1998, and 1999 yc were stocked into the Oconee River on 9 March, 19 March, and 9 July 2001. The fish were stocked at Hardwick, Balls Ferry, Avants, and Beaverdam WMA and varied in length from 212 to 361 mm and in weight from 119 to 573 g. All stocked fish previously had been batch tagged with coded-wire tags to designate year class and all received a PIT tag prior to stocking which identified individual fish.

Table 1. Robust redhorse stockings, Oconee River, 2000 – 2001.

Date Stocked	Location	Year Class	Number Stocked	Average Length (mm)	Average Weight (g)
23 Feb. 2000	Hardwick, Balls	1995	36	362 (14 in)	615 (1.4 lbs)
	Ferry, Beaverdam	1997	54	283 (11 in.)	293 (0.6 lbs)
	WMA	1998	2	268 (10 in)	225 (0.5 lbs)
			92 subtotal		
9 Mar. 2001	Hardwick	1997	5	334 (13 in.)	466 (1.0 lbs)
		1999	17	212 (8 in)	119 (0.3 lbs)
			22 subtotal		
19 Mar. 2001	Balls Ferry	1995	10	361 (14 in.)	573 (1.3 lbs)
		1997	7	292 (11 in.)	282 (0.6 lbs)
		1999	1	268 (10 in.)	200 (0.4 lbs)
			18 subtotal		
9 Jul. 2001	Avants, Beaverdam	1998	4	274 (11 in.)	239 (0.5 lbs)
	WMA	1999	41	241 (9 in.)	172 (0.4 lbs)
			45 subtotal		
		1995	46	361 (14 in.)	606 (1.3 lbs)
		1997	66	288 (11 in.)	305 (0.7 lbs)
Totals		1998	6	272 (11 in.)	235 (0.5 lbs)
		1999	59	234 (9 in.)	158 (0.3 lbs)
			177 Total		

Four stocked robust redhorse have been recaptured from the Oconee River to date (Table 2). A 425 mm juvenile stocked on 23 February 2000 and recaptured on 2 May 2000 grew 11 mm and increased in weight by 200 g. Two 272 and 410 mm juveniles also stocked on 23 February 2000 were recaptured on 1 May 2001. The growth increment during the 15 months at large was 149 mm and 926 g for the smaller fish and 100 mm and 1,600 g for the larger fish. Among the 4



recaptures of stocked fish, distances traveled between release and recapture locations varied from 2.1 to 61.3 km. Detailed post-stocking information is unavailable for one recapture due to the loss of the PIT tag.

Table 2. Recaptures of robust redhorse in the Oconee River to date.

Year	Number Stocked (Cumulative)[1]	Number Stocked Captured (no/hr)	Percent Stocked Recaptured	Total Number Captured (no/hr)[2]	Percent Sample from Stocked Fish	Number New Recruits[3]	Number New Recruits from Stocked Fish	Percent New Recruitment from Stocked Fish
2000	92 (1995, 1997, 1998 yc)	1 (0.06)	1.1	70 (5.1)	1.4	4	1	25
2001	132 (1995, 1997, 1998, 1999 yc)	3 (0.14)	2.3	46 (2.8)	6.5	4	3	75
Total	132	4	3.0	116	3.4	8	4	50

[1] Prior to sampling in April – May of each year.
[2] All sampling conducted during broodfish collection efforts in April-May.
[3] Less than 520 mm.

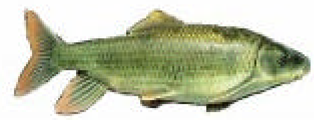
The 4 recaptures represent 4% of the 132 stocked fish at large when sampling was conducted in May 2001 (Table 3). Data collected to date provides evidence for exceptional growth and significant survival of robust redhorse stocked as larger juveniles. Additional research is needed to determine if Phase I fingerling stockings are equally successful.

Table 3. Four recaptures from Oconee River.

Year Class	Date Stocked	Date Collected	Length at Stocking (mm)	Length at Recapture (mm)	Growth (mm)	Stocking Weight (g)	Recapture Weight (g)	Growth (g)	Distance Traveled (km)
1995	23 Feb 2000	2 May 2000	425 (16.7 in)	436 (17.2 in)	11 (0.4 in)	1,120 (2.5lbs)	1,320 (2.9 lbs)	200 (0.4 lbs)	2.1 (up)
1995	23 Feb 2000	1 May 2001	410 (16.1 in)	510 (20.1 in)	100 (3.9 in)	900 (2.0 lbs)	2,500 (5.5 lbs)	1,600 (3.5 lbs)	7.5 (up)
1997	23 Feb 2000	1 May 2001	272 (10.7 in)	421 (16.6 in)	149 (5.9 in)	234 (0.5 lbs)	1,160 (2.5 lbs)	926 (2.0 lbs)	61.3 (down)
1995	NA	7 May 2001	NA	360 (14.2 in)	NA	NA	860 (1.9 lbs)	NA	NA

Spawning Results, 2001 – Greg Looney, USFWS

Capture of broodfish began April 23, 2001 and was conducted weekly for 5 consecutive weeks. Most of the fish captured were not in spawning condition, probably due to water temperature extremes and fluctuations. There apparently was spawning activity going on in the river because some females were captured with ripe eggs. As an example of the effects of the climatic conditions on the spawning condition of the robust redhorse in the Oconee, for the first 3 to 4 weeks of sampling, the average was 1 female captured for every 9 males captured. Compare this



to the historical average of 1 female for every 2 to 3 males captured. In addition, most of the males captured either did not have flowing sperm or, upon examination, the sperm was of poor quality with low or no motility.

During the week of April 23rd, 3 male and 3 female robust were captured. The most advanced of the 3 females (range 15% - 25%) had lost only 25% of her mucus and was not a good candidate for induced spawning. This was especially so in light of the fact that cooler than normal air temperatures were predicted for the remainder of the week which would have had a negative impact on the effectiveness of the hormone. Several of the fish had faint tubercles, which at times made it difficult to differentiate males from females.

In the week of April 30, 1 naturally spawning female, and 13 males (including 1 hatchery release) were sent to the spawning facility. The hatchery released male produced motile sperm. The female had lost approximately 30% - 40% of her mucus and was releasing eggs. Eggs were taken from her on April 30 and fertilized with sperm from multiple males. All of the eggs were shipped to Warm Springs National Fish Hatchery (NFH) for incubation. An additional attempt was made on May 1 to remove eggs from this female. Those eggs were also fertilized by multiple males and shipped to Warm Springs NFH. This female produced 25,643 eggs. She was mated to a total of 7 different males. These eggs produced 11,864 fry that were sent to the Walton State Fish Hatchery (SFH) for rearing.

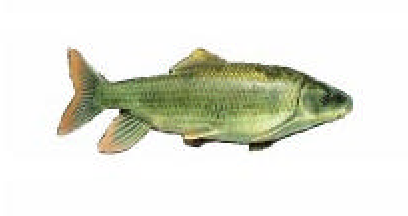
On Monday, May 7, only 1 captured male was sent to the spawning facility. He was held for a short time, sperm was collected and then released. No females were captured that day and no additional attempts were made that week to capture broodfish.

On Monday and Tuesday of the week of May 14, 10 males and 2 females were sent to the spawning facility. The female captured on May 14 was releasing eggs (~3,000), which were stripped and fertilized with the sperm from 3 males. The female captured on May 15 had lost 50% - 60% of her mucus and was injected with Ovaprim to induce ovulation. Even after receiving an additional ½ dose of Ovaprim 2 days later, the female's spawning condition deteriorated. By Friday morning her mucus loss was estimated at 10%. At that time she was released.

Of the fish captured on May 21, none were sent to the riverbank because they did not meet eligibility criteria for spawning.

No studies were undertaken with eggs of robust redhorse this year due to the scarcity of eggs and the poor quality of sperm. The sperm from several suitable males was cryopreserved and added to the embryonic robust redhorse sperm repository at the Warm Springs Fish Technology Center (FTC).

S U P P L E M E N T A L   B R E E D I N G



Cryopreservation Activities Update – Greg Looney, USFWS

The focus of activities in 2001 was designed to refine the current protocols for cryopreservation of robust redhorse sperm. The first factor to be tested was a comparison of the 2 extenders, Hanks' Balanced Salt Solution (HBSS) and 189M, to determine which produced the highest fertilization rate when used in cryopreservation. The second factor to be tested was determining the best ratio of sperm to extended cryoprotectant that produces the highest fertilization rate. The 3 ratios to be tested were 1:5, 1:7, and 1:10, sperm to extended cryoprotectant. Past studies have shown that dimethyl sulfoxide (DMSO) at 10% of the total concentration to be the cryoprotectant of choice. HBSS is the extender of choice for refrigerated storage.

The sperm from 6 males was used in these tests. Sufficient numbers of samples were preserved so that extra samples would remain after the testing for inclusion in the robust redhorse sperm repository. Due to the overall poor quality of sperm collected this year, these were the only samples placed in the repository. Due to the short supply of eggs this year, eggs were not available for research use. These study samples will remain in the repository for use next year if these studies are continued or they can remain as archival samples.

Refrigerated Storage Activities

The first test had 3 males. The unextended sperm was retained for study and possible use if a suitable female was captured but the sperm only retained sufficient motility to reliably fertilize eggs for 3 days. Extender HBSS was added to sub-samples on day 3 to test the possibility of retaining motility for a longer period. There was no sperm motility in any of the 3 extended samples on the following day (Figure 6).

The second test was with a single male whose sperm was compared in an extended and unextended state beginning at the time of collection. Retained motility of the unextended sample was poor with no motility 24 hours post collection. The extended sample retained 85% motility at the 24-hour check but had no motility at the 48-hour check (Figure 7).

Figure 6. Use of HBSS extender on day 3.

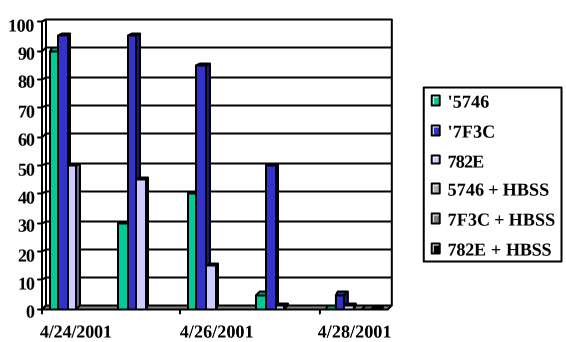
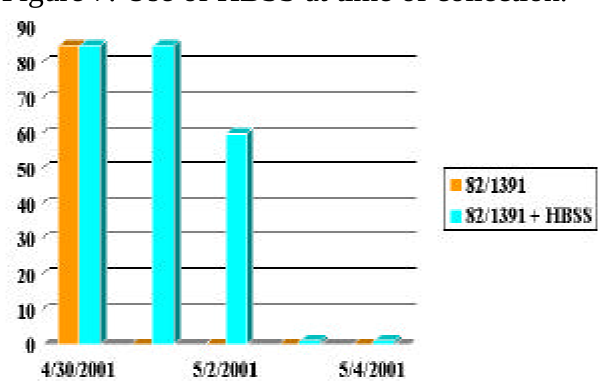
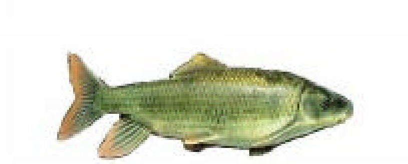


Figure 7. Use of HBSS at time of collection.





The next test was a repeat of the second with another male (80% motility) but with a twist. Not only was HBSS added to a sub-sample at collection but to an additional sub-sample at 24 hours post collection. The unextended sperm retained 85% motility at 24 hours but had no motility at the 48-hour examination. The first extended sample retained 90% at 24 hour, 80% at 48 hour, 80% at 72 hours, 35% at 96 hours, 30% at 120 hours, and <1% at 144 hours. Meanwhile, the second extended sample (extended at 24 hours post collection) retained 40% (from 80% down to 40%) at 24 hours, 50% at 48 hours, 15% at 72 hours, 5% at 96 hours, and <1% at 120 hours (Figure 8).

The sperm from another male was extended with HBSS at 48 hours post collection (40% motility). Twenty-four hours later the extended sperm had <1% motility while the unextended sperm retained 40%.

The next test was a repeat of previous tests. In this case, the sperm from 3 males was extended at the time of collection and evaluated against the unextended sperm over time. The unextended sperm began a major loss of motility at 48 to 96 hours while the extended sperm exhibited a more gradual decline in motility. By 96 hours the unextended sperm was of a quality that would be unsuitable for production use while the extended sperm retained sufficient motility at 120 hours that would allow for use in production (Figure 9).

Figure 8. HBSS at collection with a twist.

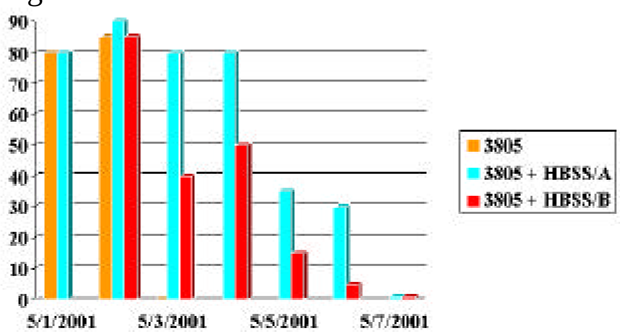
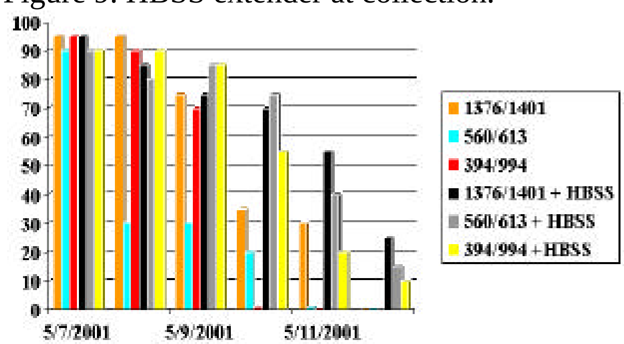
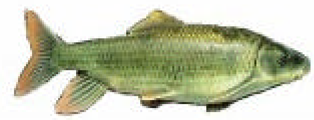


Figure 9. HBSS extender at collection.



This test was undertaken on May 14 when several males were captured and most were determined to have very poor sperm motilities. In an effort to gain additional information, samples from 12 males were put into refrigerated storage. At the same time sub-samples were extended either at 1:3 or 1:5 with HBSS to determine if motility over time was different than the controls. There was no difference in storage time or retained motility between the 2 ratios tested. Again, the extended samples retained motility longer than the unextended samples.

The final test was to determine the effect of Ovaprim injections on male robust redhorse. The factors monitored were storage time, retained motility, and total volume over time. The manufacturer’s recommended rate of 0.5 ml/kg was used. There wasn’t any advantage to the use of Ovaprim injections to improve storage time or retained motility but there appears to be an increase in total volume of sperm at 2 and 3 days post injection. This test needs to be repeated



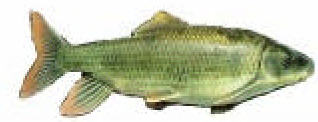
under more controlled conditions to determine any significant advantages to hormone application for male robust redhorse broodfish during years of poor sperm quality.

Fingerling Distribution and Fry Production – Jay Shelton, UGA

A presentation summary on fingerling distribution and fry production was not submitted but meeting attendees recorded the following discussion points.

One of the hatchery ponds experienced a large die off affecting both robust redhorse and tadpoles. There was evidence of external bacteria infection but the cause of the die off was not determined and potassium permanganate helped.

H A B I T A T &
P O P U L A T I O N D Y N A M I C S



Evaluation of Spawning Aggregates, Oconee and Savannah rivers – Bud Freeman, UGA

A presentation summary on spawning aggregates in the Oconee and Savannah rivers was not submitted but meeting attendees recorded the following notes.

Dr. Freeman provided video footage of spawning aggregates of robust redhorse, which primarily spawn in coarse gravel but also use sand to gravel of 60 mm. Some fish exhibited porpoise behavior prior to spawning. At spawning aggregates, females can be observed selecting from among the available males but which features they are selecting for remains unknown. The life span of robust redhorse is 20 to 25 years.

The Avants site is upstream of where broodfish are collected on the Oconee River and has been considered a refugial area of the river. Some tagging was conducted in the Avants during 1993 and 1994. In a given year, one or two tagged fish are observed in this area.

Robust Redhorse Database of Captures – Bob Jenkins, RC

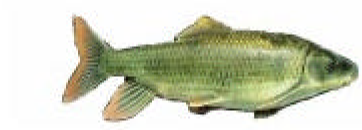
The database (DB) of captures was developed from sampling for robust redhorse by shockerboat in and near its 1992 - 2001 spawning periods; fish captured at other times of the year are included for 1991 - 1992. The data were input from field records made by or under direction of Jimmy Evans and Greg Looney while on-river and, for many fish, while held for gamete collection for one to several days in tanks at the Beaver Dam WMA. Jimmy Evans started the DB using QuattroPro. In late 1998 Dr. Jenkins imported it to Excel, reformatted it, and checked accuracy of data-input against original data; in 2001 he added the 2000-01 data.

The total of records (captures) is 1013 (including 4 stocked fish caught in 2000-2001), representing maximally 690 fish, and including 323 recaptures (excluding the first capture of each recaptured fish) determined by PIT tags. Minimally 194 fish were captured twice to at least 6 times. Minimally 15 fish have an incomplete recapture history owing to tag-loss, -reading, or -recording problems.

Uses of the DB include determining (1) catch per effort (by years and river reaches); (2) population trends and density estimates; (3) across-years trend in fish size; (4) recruitment; (5) centers of abundance, range shifts, and homing; (6) sex ratio; (7) iteroparity by years; and (8) growth in length between captures of recaptured fish (for comparison with growth determined by back-calculation).

Added to the DB as separate worksheets are (1) all individual-fish recapture histories; (2) mortality documentation; (3) list of Oconee River reaches, river miles, and other descriptors of sampling sites; and (4) a DB of Savannah River captures of robust redhorse.

HABITAT & POPULATION DYNAMICS



The oldest fish ever captured was 27 years. On average, captured males are 19 and captured females are 17 years old. Males mature as young as 3 to 4 years of age, while females mature at about 5 years of age. The oldest stocked fish are 3 to 4 years in the Broad River, Georgia.

Robust Redhorse Abundance Indices, Oconee River – Jimmy Evans, GA DNR

The abundance of robust redhorse in the Oconee River is evaluated annually through population estimates calculated from recaptures of marked fish and by analyses of electrofishing catch rates. Since 1993, all robust redhorse captured during spring broodfish collection efforts have been tagged with either Floy dart tags alone or with a combination of Floy and PIT tags. Throughout each broodfish collection season, all fish are examined for tags, previously tagged fish are enumerated, and all untagged fish receive tags. These data are summarized in a mark-recapture matrix and the formulas of Jolly and Seber are used to determine annual estimates of the number of fish in the population, the survival rate, and the number of fish entering the population. This presentation concerns only the population estimates for the period 1995 – 2000. A population estimate is not available for 2001 since mark-recapture methods can provide estimates only for the year prior to the most recent sampling occasion. In addition, since robust redhorse smaller than 400 mm total length (TL) have not been collected, all population estimates are only for fish greater than 400 mm TL.

Estimates of the robust redhorse population greater than 400 mm TL for the1995 – 2000 period varied from 355 to 514 (Figure 10). The lowest population estimates were in 1996 and 1999 and the highest in 1998. The most recent estimate was 362 fish for year 2000. Standard errors were generally low with percent standard errors ranging from a high of 18% in 1996 through 1998 to a low of 14% in 1995. Since the broodfish sampling used to estimate population size is conducted in only about 60% of the reach known to contain robust redhorse, actual abundance is undoubtedly somewhat higher. A very rough correction factor would add 40% to the population estimate for each year. The most recent estimate would therefore be 507 fish greater than 400 mm TL for the year 2000. Analysis of long-term trends showed no correlation between population estimates and electrofishing catch rates (Figure 11).

Figure 10. Oconee River population estimates.

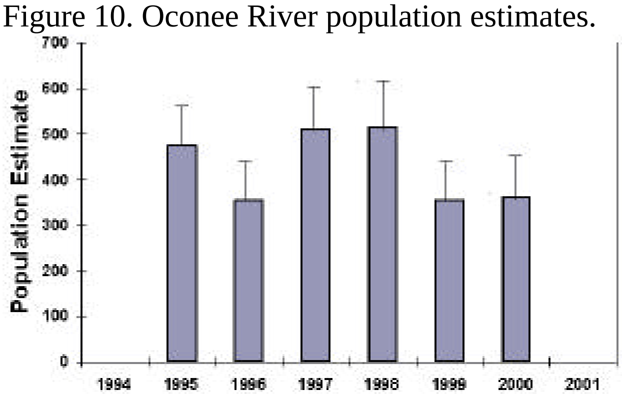
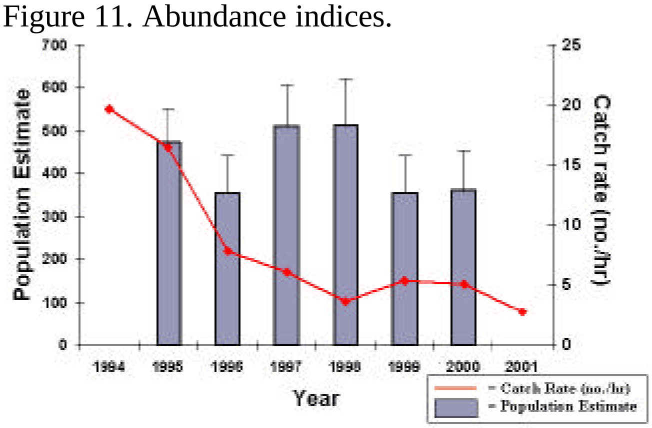
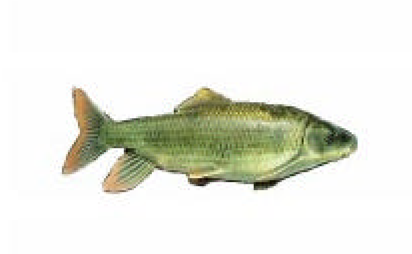


Figure 11. Abundance indices.



HABITAT &
POPULATION DYNAMICS

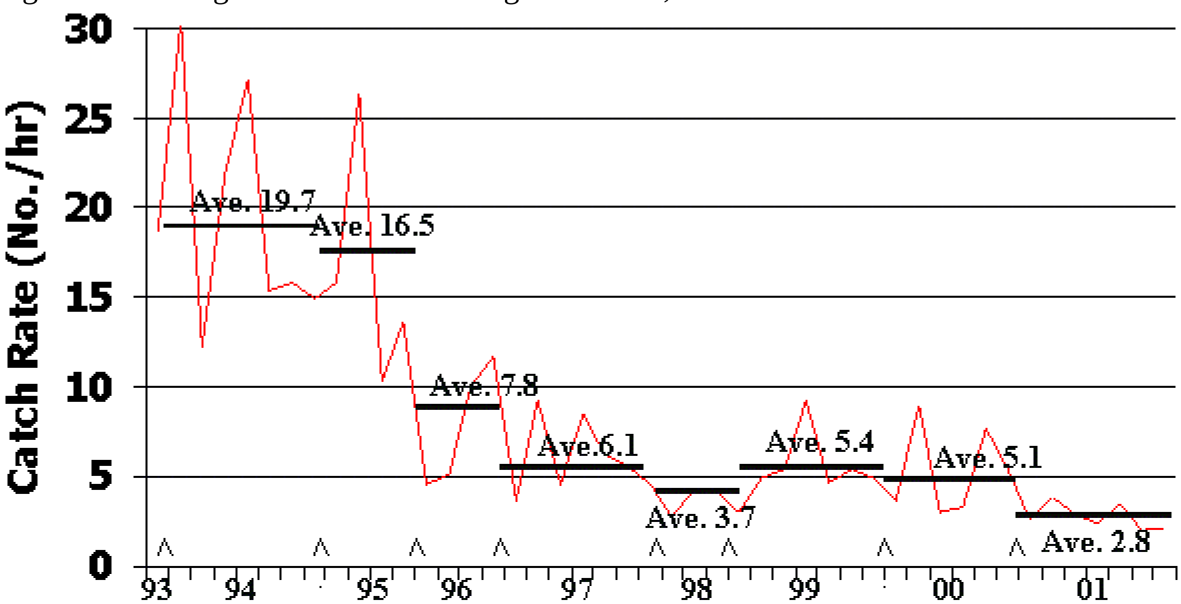


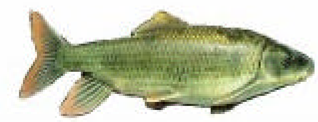
The non-random sampling required to collect broodfish may bias the estimation of population size. This bias may not be significant, however, since most of the known range of the robust redhorse in the Oconee River is thoroughly sampled during spring broodfish collection efforts. To avoid unneeded electrofishing stress, additional sampling specifically designed to estimate population size is not conducted.

Electrofishing catch rates have been extensively used as a relative index of population abundance for numerous fish species. On the Oconee River, robust redhorse electrofishing catch rates are calculated for each sampling date and for the entire broodfish collection season. The Georgia Power Company (GPC) provides low flows on scheduled broodfish collection dates to improve sampling efficiency. Sampling is sometimes conducted during higher flows to monitor the condition of broodfish but only the sampling conducted during controlled flows was used to calculate annual electrofishing catch rates. The volume of flow during controlled broodfish collection is similar within and between years and both electrofishing gear and sampling crews have been standardized since 1992.

Average annual electrofishing catch rates during the 1994 to 2001 period varied from a high of 19.7 fish per hour in 1994 to a low of 2.8 fish per hour in 2001 (Figure 12). Analysis of variance indicated that the pattern of declining catch rates was highly significant ($p < 0.01$). Scheffe's and Tukey's means comparison tests showed that catch rates for 1994 and 1995 were not significantly different from each other but that the rates for these years were significantly higher than those for 1997 through 2001. The year 1996 was transitional between the higher catch rates observed in 1994 - 1995 and the lower catch rates characteristic of the 1997 – 2001 period. Average annual catch rates during the 1997 – 2001 period were not significantly different. The year 1993 is excluded from the statistical analysis since catch rates are available for only one sampling date.

Figure 12. Average annual electrofishing catch rates, 1993 – 2001.





Although flows are regulated to nearly equivalent levels on all sampling occasions and electrofishing crews and gear are standardized, there are occasional biases in the collection of catch rate data. Unusual temperature regimes prior to or during the initiation of spawning activity may influence the abundance, and therefore the catch rates, of fish in the spawning aggregations normally sampled for broodfish.

Discussion Points

The population model uses 60% as the year-to-year survival rate estimate. The 2000 RRCC Annual Meeting Report includes the model's estimate of mortality and recruitment rates. There were unique factors in 1997 that affected the catch rates; the discharges from the Lake Sinclair were altered so that the flow rates in the Oconee River were different. To the extent that this variation can be addressed, it is included in the modeling.

Reproduction and Recruitment Success in the Oconee River – Cecil Jennings, USGS

A presentation summary on reproduction and recruitment success in the Oconee River was not submitted but meeting attendees recorded the following discussion points.

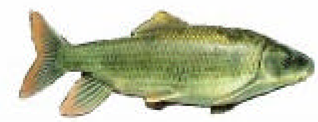
Robust redhorse tend to swim-up at approximately 11-12 mm. Strong year classes have been detected in years with lower river flows. Early evidence suggests that estimates are actual abundance and not sample efficiency related to river flows. This is based on catch of older individuals reflecting a peak in younger individuals caught earlier. The maximum size of a captured robust redhorse was 760 mm TL and 7 kg. Investigators explored but did not find any juvenile robust redhorse in backwater oxbows of the Oconee River, although other juvenile suckers were captured.

Flow Advisory Team Update – Mike Nichols, GPC

The following excerpts the 2001 Flow Advisory Team (Team) meeting summary, compiled by Scott Hendricks. The purpose of the meeting was to discuss robust redhorse information collected to date in the Oconee River and address the adequacy of the Lake Sinclair licensed Flow Agreement in meeting the needs of the species.

The GPC's Federal Energy Regulatory Commission (FERC) license for the Sinclair Project includes articles (401 and 404) that pertain to the Flow Agreement for the Oconee River and the Team. Under the license, GPC is required to provide every two years, a progress report to the FERC, developed in coordination with the Team, which summarizes the status of the robust redhorse and makes a determination on the adequacy of flow releases in meeting the needs of the species. Reports were submitted in 1998 and 2000; the next progress report will be submitted by March 2002.

HABITAT & POPULATION DYNAMICS

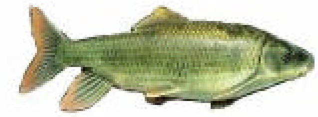


Results of recent laboratory studies of temperature and flow effects on egg and larval survival noted that high water temperatures could limit survival. The Team discussed how river temperatures could be influenced by the Sinclair flow regime and the highly variable hydrologic conditions in the Oconee basin during the last several years. Reducing flows in May for broodfish collection (as opposed to run-of-river flows) could also result in a temperature rise. It was noted that the larvae sometimes have a prolonged swim-up period that extends into June, when water temperatures are higher and flows are more variable. The relationship between temperatures, flow regime, and reproductive success in the river are unclear, and there is limited continuous temperature data available.

Pete Lasier's *Contaminant Impacts to Early Life Stages of the Robust Redhorse (Moxostoma robustum) in the Lower Oconee River* suggests that manganese (Mn) concentrations in the gravel could adversely affect survival of early life stages of robust redhorse. In addition, other studies have associated Mn with salmonid mortalities. The Oconee River study did not attempt to address Mn concentrations relative to flows or speculate on a source of Mn. It is unclear how Mn concentrations could be alleviated by flows assuming it is a significant issue. The applicability of flushing flows for the Oconee River immediately prior to spawning season, the ability of their provision from the Sinclair Project, and potential effects on sediment and contaminants was discussed in consideration of promoting better water quality within the gravel spawning sites. There is evidence from earlier freeze core studies that the spawning act of robust redhorse displaces much sediment from a small, localized area, which may serve to clean the gravel of excessive fine sediments before egg deposition.

Preliminary results of the reproductive and recruitment success studies, ongoing since 1995, were presented. Monitoring in the Oconee River with various larval fish collection devices and some young of year (YOY) and juvenile fish collection have resulted in preliminary comparisons of spring Oconee River flows near Avant Mine with numbers of larval robust redhorse (or Moxostoma as a group) collected. The 1995 and 1996 collections, conducted under the pre-relicensing flow regime from the Sinclair Project, resulted in the capture of 7 and 6 robust redhorse larvae, respectively. Studies in years 1997, 1998, and 1999 were conducted under the new flow agreement. In 1999 many more fish of several species were observed than in past years apparently indicating large year classes. This production may be related to the very low river flow, although there could be better sampling efficiency at lower flows. Year 2001 flow was relatively stable, somewhat similar to flow patterns observed in 1997 and 1999. Year 2000 and 2001 data had not been fully counted.

It remains too early in data collection to fairly evaluate the new flow regime. The inability to capture YOY robust redhorse, for whatever reason, complicates assessment. However, an increase in catch of larval robust redhorse was observed in the 1997 monitoring. Four years later, a similar increase in catch of robust redhorse about 400 mm TL was made from the Oconee River. Larval fish sampling continues to be a primary tool to evaluate the success of the new flow regime. Off-channel habitats, tributaries, oxbows, and downstream sections of the river were identified as the best next step in targeting sampling to locate YOY and/or juvenile robust redhorse.



Discussion of other approaches included (1) using the robust redhorse DB of captures to pinpoint when large year classes were produced and evaluate the flow conditions present at that time, or (2) using an ultrasound probe to delineate opercle rings to allow aging without sacrificing the fish and provide a better age sample of the existing population. In addition, the merit of evaluating the last 20 - 30 years of flow data on the Oconee River was considered. It was noted that several other important things have happened over that time that could affect robust redhorse reproduction and recruitment including the invasion of corbicula, the invasion of flathead catfish (although it is not obvious they are a predator of concern as robust redhorse have not been found in their stomachs), changes in land use, and nutrient loading. The few attempts to evaluate Oconee River flow data over the past 20 - 30 years have thus far not yielded conclusive results. In fact, cursory evaluations do not reveal much difference in Oconee River flows pre- and post-Wallace dam (Lake Sinclair), although timing of flows rather than magnitude may be the important variable.

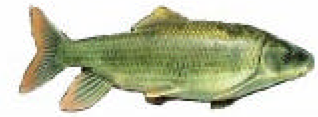
The Team agreed there is not enough solid information yet to determine the adequacy of the new flow regime in meeting the needs of robust redhorse. However, the Team believes there is evidence that indicates, at least preliminarily, that the new flow regime is having positive effects on reproduction and recruitment of many Oconee River species. The difficult task will be separating the effects of the drought conditions from the effects of the new flow regime. The Team also agreed that larval sampling should remain a high priority and that YOY and juvenile sampling in downstream and off-channel habitats is also important.

Efforts to Restore Razorback Sucker in the Green River, Utah – Tim Modde, USFWS

The razorback sucker (*Xyrauchen texanus)* is a long-lived, monotypic species, endemic to the Colorado River Basin. The razorback sucker occupies main channel habitats as adults but its young are believed to be dependent on floodplains for nursery habitats. The decline of razorback sucker in the Colorado River Basin coincided with major environmental changes following the construction of large mainstem dams and establishment of nonnative fishes, which quickly invaded the modified river. Following construction of mainstem dams on the Colorado River, floodplain habitat was dramatically reduced by declines in the magnitude and duration of spring flood flows. Prior to Flaming Gorge Dam, the mean annual peak discharge of the Green River at Jensen, Utah was 680 m^3/s compared to 493 m^3/s following dam construction. Following operation of Flaming Gorge Dam the duration of overbank discharge has decreased substantially. The inability of razorback sucker larvae to access off-channel nursery habitats has prevented recruitment sufficient to sustain population size.

Recovery efforts for the razorback sucker operate under the auspices of the Recovery Implementation Program for the Recovery of Endangered Fishes in the Upper Colorado River Basin. This program is a consortium consisting of 3 states, 4 federal agencies, and 3 private entities representing the range of water-related interests in the Upper Colorado River Basin affected by the impacts of the Endangered Species Act. This recovery program is charged with recovering the 4 large river fishes in the Upper Colorado River Basin: razorback sucker,

H A B I T A T &
P O P U L A T I O N D Y N A M I C S



Colorado pikeminnow (*Ptychocheilus lucius)*, bonytail (*Gila elegans)*, and humpback chub (*G. cypha)*. The primary components of the recovery program include habitat restoration, protection of instream flows, reduction in the influence of invasive species, propagation and genetics, and population monitoring. Razorback sucker restoration efforts are focused on increasing larval access to off-channel nursery sites and increasing the number of spawning adults. Specific restoration actions include flow management (i.e., magnitude, duration, and timing) through reoperation of Flaming Gorge Dam and breaching of artificial dikes around large off-channel depressions, together with augmentation of the wild population with hatchery-reared fish.

Discussion Points

It is now believed that the larvae of the razorback sucker spend 2 years in the off river floodplains before re-entering the river, therefore, floodplain restoration, connections to floodplains, and management of flows are critical.

It is not so much the current versus historical flow rates of the river but that the river now runs like a canal in a set channel. In the past, the river flooded and flowed outside its normal channel connecting to the floodplains. Now the larvae cannot get out of the river into the floodplain areas and return to the river.

The main issue to affect restoration of the species is recruitment, not reestablishing ponds in the floodplains. The key seems to be the larval stage. If they can make it through the first year or 2 they will most likely avoid predation and will be more likely to survive to recruitment.

Generally, spawning sites for this fish are in the upper end of the alluvial reach at the confluence of the 2 tributaries. The larvae are so small and have such a small yolk sac that they are probably passive drifters. But once they are in the backwater areas of the floodplain they actively move to slower water.

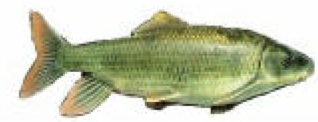
In 1995, the population estimate was believed to be about 500. The number of adults is declining and regular monitoring, conducted since the 1970s, shows that the recruitment rate is sub-optimal.

The monitoring is not good enough in all areas to determine what percentage of the fish is hatchery-reared. Monitoring is now undertaken in such a way as to get the best possible population estimates but a definition of recovery still must be agreed upon.

Telemetry Evaluations on the Oconee River – Cecil Jennings, USGS

A presentation summary on telemetry evaluations on the Oconee River was not submitted but meeting attendees recorded the following discussion points.

H A B I T A T & P O P U L A T I O N D Y N A M I C S



Hatchery produced fish between 300 – 500 mm were used in the telemetry evaluation. Half did not move much, the other half moved from 1 - 70 m. All fish died by the end of summer, which makes it difficult to interpret the meaning of the movement. Transmitters were externally attached. However, the fish were exposed to large amounts of handling and the Oconee River suffered drought conditions. It appears that minimal handling, rather than attachment method, may be critical to robust redhorse survival during telemetry and other studies.

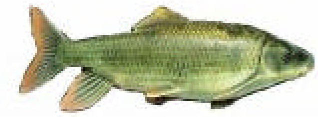
While sampling the Savannah River for shad, Dr. Isely found hundreds of robust redhorse in spawning areas and placed a telemetry device in 1 fish that was inadvertently captured. The fish was tracked for 90 days as it moved, initially back to the gravel bar it had been collected from, then downstream about 4.5 miles a few hours later. In some instances, the fish remained in deep pools of about 30 feet and in mid June, it moved up river again. Additional telemetry studies in the Savannah River may provide valuable information on movement and habitat use.

Strontium/Calcium Ratios in Robust Redhorse Otoliths – Dave Coughlin and Mark Rash, DPC and Dr. Karin Limburg, SUNY College of Environmental Science and Forestry

The robust redhorse occupies a portion of its former range. The current distribution might appropriately be called coastal since the remaining wild populations are found in rivers from the seacoast upstream to the first impassable barrier. Despite this limited range, speculation arises on the whereabouts of this fish for vast periods of its life history. Collection of fish ranging in size from approximately 14 to 400 mm TL is unknown and it is generally perceived that robust redhorse, like most suckers, do not use saline environments. The combination of these two obstacles, along with the extreme difficulty in sampling this species (it is immune to traditional boat mounted electrofishing techniques at most times except when in shallow water to spawn), indicates a real lack of information on the basic movement patterns of this fish. Indeed, considering its shrouded history and taxonomy, there is a lack of basic biological knowledge on the robust redhorse.

In an attempt to scientifically evaluate the potential use of saline environments by robust redhorse, the following information on robust redhorse and related species have been collected and summarized. Despite the collection of Cope's original specimen in the Yadkin River (far inland from the current remnant population in the Pee Dee River) there have been no collections of the species above the first impassable barrier at Blewett Falls Dam in North Carolina. Indeed, in all river systems within the historic range there have been no known collections of robust redhorse above the first impassable barrier. The difficulty sampling this species, despite the considerable effort that has been expended searching for it, must always caveat this lack of occurrence. However, numerous other catostomid species survive today above these impassable barriers and appear to be in no danger of becoming threatened. The question begs to be asked: Is the current coastal distribution of robust redhorse an indication of some benefit derived from spending time in or near saline environments?

HABITAT & POPULATION DYNAMICS

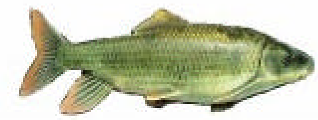


Despite the general impression that suckers are strictly freshwater species, several authors would indicate otherwise. Texts by Jenkins and Burkhead (1993) and Murdy et al. (1997) indicate some use of saline environments by catostomid species. Murdy et al. (1997) note 3 species that spend time in the Chesapeake Bay and discuss quillback (*Carpiodes cyprinus)* tolerating salinities as high as 11 parts per thousand (ppt). Laboratory studies of the tolerance of juvenile robust redhorse to various physiological stressors have been recently performed. Walsh et al. (1998) found that juveniles could withstand acute salinity exposure up to 9 ppt and chronic salinity exposure in the 12 – 16 ppt range. Clearly there is evidence that robust redhorse can tolerate some amount of salinity while indirect evidence suggests they cannot tolerate full strength seawater. The genetic divergence study of Wirgin (2001) indicates that robust redhorse probably do not tolerate full strength seawater as populations in the Savannah and Altamaha drainages have been separated for some amount of geologic time.

All of the above information makes for neat speculation about robust redhorse use of saline environments especially considering the fact that a large sucker was caught at river mile 24.5 (near the salt wedge) in the Savannah River in October 1997 (Bill Post, SCDNR, Marine Resources Research Institute, Sturgeon Project, personal communication). The sucker was approximately 450 mm long with a shiny greenish body and red fins. It was noted as bycatch at the time and released. Mr. Post and a fellow fishery biologist both realized what they had captured upon seeing photos of robust redhorse at the 2000 Southern Division of the American Fisheries Society (SDAFS) Mid-year Meeting in Savannah, Georgia. They approached members of the RRCC to discuss their sighting. While quite possibly a robust redhorse, skepticism continues about robust redhorse use of saline environments. This skepticism has led to this evaluation of the microchemistry of robust redhorse otoliths as a way to document use of saline environments.

The ratios of Strontium/Calcium (Sr/Ca) in various layers or annuli of fish otoliths have been used by a variety of researchers to document anadromy and catadromy in fish. The technique relies on the ability of Sr and Ca to be deposited interchangeably in the aragonite matrix of the otolith and the concentration of Sr being a couple orders of magnitude greater in saltwater than in freshwater. Thus a fish that has spent some time in a saltwater environment will have a higher Sr/Ca ratio in that portion of the otolith corresponding to seawater residence compared to the portion coinciding with freshwater residence. Otolith microchemistry could prove quite useful in evaluating use of saline environments by robust redhorse.

Information on the microchemical analysis of otoliths (lapilli) from 5 mature Oconee River robust redhorse have been presented previously and only will be summarized here. The 3 male and 2 female fish show non-uniform strontium accumulation throughout life. This would indicate that they probably move between environments with low and high (relatively speaking) concentrations of Sr. The 3 fish all appeared to live in a low Sr environment early in life and make some type of movement to an area of high Sr concentration around the time of maturation (annuli 4 or 5). The use of the high Sr environment later in life ranges from virtually nil to quite extensive. The findings are intriguing and could have great benefit to the recovery effort if they are real.



Yet this Sr may result from some source of Sr pollution in freshwater and not seawater. Concerns about the source of the Sr recorded in these robust redhorse otoliths has led the investigators to team with Dr. Fred Andrus (University of Georgia, Department of Geology) to examine the geology of the Altamaha drainage. This effort will take place in late 2001 and will include a series of water samples from the tailrace of the Sinclair Dam to Brunswick, Georgia to look for rogue sources of Sr. The analyses will be conducted via Inductively Coupled Plasma (ICP) at the Duke Power Company Analytical Lab. These results, in addition to Sr/Ca ratio analyses of otoliths from pond-reared control fish, will be forthcoming and may help us further elucidate the sources of Sr encountered by robust redhorse. Ultimately, whether ranging to saline environments or not, this study should provide information on the movement patterns of robust redhorse.

Literature Cited

Jenkins, R. E., and N. M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland.

Murdy, E. O., R. S. Birdsong, and J. A. Musick. 1997. Fishes of Chesapeake Bay. Smithsonian Institution Press, Washington, D.C.

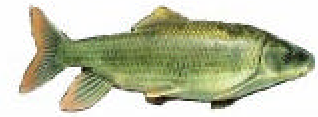
Walsh, S. J., D. C. Haney, C. M. Timmerman, and R. M. Dorazio. 1998. Physiological tolerances of juvenile robust redhorse, *Moxostoma robustum*: conservation implications for an imperiled species. Environmental Biology of Fishes 51:429-444.

Wirgin, I., T. Opperman, and J. Stabile. 2001. Genetic divergence of robust redhorse *Moxostoma robustum* (Cypriniformes Catastomidae) from the Oconee River and the Savannah River based on mitochondrial DNA control region sequences. Copeia 2001:526-530.

Discussion Points

Historically, robust redhorse resided above the fall line. The analysis of strontium patterns observed in the otoliths has worked well with other species. It is possible that a finer tool may be needed to show results for the robust redhorse.

Silver redhorse are known to be saltwater intolerant. If similar strontium patterns appear in that fish, it might indicate a river source causing these patterns. Springs along the Oconee River could be the source of different strontium levels.



2001 Robust Redhorse Pond Monitoring Efforts at Piedmont National Wildlife Refuge – Greg Walmsley and Laurel Dowswell, USFWS

Five ponds at Piedmont National Wildlife Refuge (PNWR) have served as refugial holding ponds for robust redhorse since 1996. Until this year, monitoring efforts have been minimal. Based on recommendations from the RRCC, refuge staff worked to intensify monitoring efforts by hiring a temporary biological aide to conduct a monitoring program in the summer of 2001. The program included weekly surveys of water quality (including dissolved oxygen, temperature, pH, and turbidity), as well as vegetation and predator observations.

Analysis of the 2001 survey reveals poor dissolved oxygen, especially in ponds 7A, 11A, and 11B. Pippins Lake and Pond 9A appear to have the most suitable water quality; however, benthic levels are anaerobic in all 5 ponds. Aquatic vegetation concerns are minimal, except at Pond 11B, where hydrilla is present. Predation by river otters is another concern that warrants further investigation. Otter scat samples collected from the summer will be analyzed for robust redhorse scale composition. In addition, herons, but not cormorants, have been observed feeding in these ponds. Mollusks are present in the associated streams but not the ponds.

On a positive note, the refugial ponds continue to provide the RRCC with a source of stocking and broodfish for the recovery effort. In fact, 99 of the 177 of the hatchery fish released into the Oconee River have been reared in PNWR ponds. Complete survey data is available through the Piedmont NWR office.

Central Georgia Branch Station Refugial Population – Jay Shelton, UGA

A presentation summary on the refugial population at the Central Georgia Branch Station (CGBS) was not submitted but meeting attendees recorded the following discussion points.

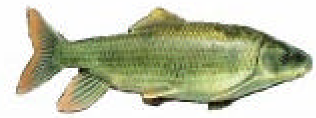
A letter of agreement was signed in 2001 to formalize the relationship between the RRCC and the CGBS to keep a refugial population in ponds on the CGBS.

All of the fish at CGBS are from Oconee River stock; some were produced through the hatchery program protocol. The fish were selected from among all of the hatcheries to get as wide a genetic range as possible, including representatives of all of the year classes at the PNWR.

Update on Hatchery Pond Culture Studies – Jay Shelton, UGA

A presentation summary on the hatchery pond culture studies was not submitted but meeting attendees recorded the following discussion points.

An update on the growth, survival, and feeding studies found survival to be dependent on low densities. Gut contents include cladocerans primarily and copepods and chironomids. The pond



with the highest survival rate showed the least utility of hatchery food (supplement with trout chow).

Discussion of Hatchery Pond Management

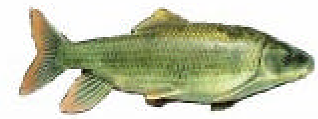
The goal of the refugial population program has evolved over time. Initially, the refugial populations were seen as a source to repopulate the Oconee River should that become necessary. Later, the Broad and Ogeechee rivers in Georgia also became a backup source of fish. Given that the hatchery ponds are available only for a growing season at a time, the refugial ponds also serve as rearing ponds to produce larger fingerlings. The plan is to keep all of the ponds that are located in the Oconee River drainage area. Pond space is adequate for now; however, in the future ponds in the Savannah River drainage will be needed to serve as refugia for Savannah River fish.

There are currently 6 refugial ponds. Generally, the older year classes are the least abundant. Although there is a fairly high loss rate year to year, no year class has been lost so far. It is not easy to get an accurate count of the year class groups in the ponds. A mark and recapture study was undertaken on 1 pond.

There is no problem with survival of fish in the wild streams after they have been raised on commercial feed (trout chow) in ponds. The re-introduced fish seem to survive at good rates and their growth rates explode.

Although the data on the PNWR ponds indicate low dissolved oxygen, there is no electricity for augmentation of those ponds and no budget or resources for electricity to be run to the ponds. Essentially they are farm ponds that are expected to have low oxygen levels at the bottom during the summer.

S T A T U S S U R V E Y S



Robust Redhorse Surveys in the Pee Dee River, North Carolina-South Carolina, 2000-2001 – John Crutchfield, CP&L

Intensive fish surveys were conducted on the Pee Dee River in North Carolina and South Carolina during the spring of 2000 and 2001. These studies were a cooperative effort of several different state and federal resource agencies, universities, museums, and power companies. The participating groups included the NC Wildlife Resources Commission, NC Division of Water Quality, NC Museum of Natural Science, SC Department of Natural Resources, US Geological Survey Cooperative Research Units at NC State University and the University of Georgia, US Fish & Wildlife Service, Duke Power Company, GPC, and Carolina Power & Light.

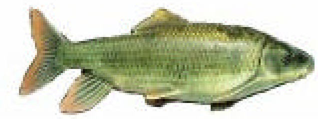
The objectives of these intensive surveys were to (1) sample identified reaches of the Pee Dee River in North Carolina-South Carolina to determine if the rare sucker species robust redhorse and Carolina redhorse (undescribed *Moxostoma* species) were present in the drainage; (2) determine, if possible, critical spawning habitat of these 2 species for future survey and research efforts; and (3) evaluate other resident and migratory fish populations present in the river.

Two reaches of the Pee Dee River were identified for the sampling efforts. Reach 1 was the 37.3 km river segment from the tailwaters of the Blewett Falls Hydroelectric Plant located in North Carolina to just downstream of Cheraw, South Carolina. Reach 2 was located upstream of Reach 1 and extended 34.6 km from the Tillery Hydroelectric Plant tailwaters to the headwaters of Blewett Falls Lake. Each reach was further divided into 3 sub-reaches for sampling based on tributary inflow, gradient, and habitat characteristics. Reach 1 was sampled during both years while Reach 2 was only sampled in 2001.

Boat electrofishers were utilized during the study and sampling was conducted over 3 - 4 consecutive days during daylight hours. Pulsed DC current was used with electrofisher settings of 60 pulses per second at approximately 400 - 500 volts and 3 - 5 amps. Sampling effort (i.e., total hours expended electrofishing) for Reach 1 was comparable between 2000 (22.5 hours) and 2001 (24.2 hours). Sampling effort was slightly lower for Reach 2 during 2001 (17.5 hours).

One robust redhorse was collected during each annual survey in the river reach below the Blewett Hydroelectric Plant (Reach 1). No robust redhorse were collected from the river reach between the Tillery Plant and Blewett Falls Lake. These fish were collected from shallow shoal habitat (1 - 2 m in depth with gravel, cobble, and boulder substrate) at locations approximately 6.4 and 17.7 km below the hydroelectric plant. The specimen collected during 2000 was 605 mm TL weighing 3.2 kg and 6 years old. The 2001 specimen was 692 mm weighing 5.6 kg and 11 years old. Both specimens were females that were either spent or ripe in reproductive status. Water temperatures at the time of capture were 17.4º C during 2000 and 19.2º C during 2001. Both fish were tagged, pelvic fin clips obtained for genetic analysis, and released near their capture sites.

Prior to these 2 collections, only 2 other records of robust redhorse were known from the Yadkin-Pee Dee River drainage. The original species description by Edward D. Cope in 1869 came from the Yadkin River portion of the river, which is located in the upper piedmont region of North



Carolina. A specimen was also collected in 1985 in the Pee Dee River, North Carolina, approximately 19 km downstream of the Blewett Plant and near the location of the 2001 capture.

These surveys also documented that the resident fish fauna in both river reaches of the Pee Dee River were dominated, in terms of biomass, by non-native species (smallmouth buffalo, blue catfish, flathead catfish, common carp, and grass carp).

Although no Carolina redhorse were collected during these intensive surveys, additional environmental studies conducted by CP&L documented this species in both reaches of the Pee Dee River during 2001. One post-spawn male was collected on shoal habitat, approximately 0.8 km below the Blewett Plant (495 mm, 1.7 g) during May. Four other specimens were collected in Blewett Falls Lake during the August-September period and these specimens included juveniles and adults (total lengths ranging from 100 to 465 mm). Prior to these collections, only 6 other Carolina redhorse have been reported from the Pee Dee River for the period of 1961 to 1994, and all of these fish were documented from the reach below the Blewett Plant (personal communication with Dr. Robert Jenkins, Roanoke College, Salem, Virginia).

Results of these surveys suggested that the current robust redhorse population inhabiting the Pee Dee River is very small, although there was some evidence of reproductive activity in this population. Although no robust redhorse were documented in the river reach below the Tillery Plant, future sampling efforts in this reach should occur later in the spring due to differences in the temperature regime.

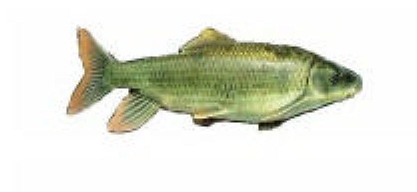
More research, including additional surveys, is needed to further assess the status of robust redhorse and Carolina redhorse populations in the Yadkin-Pee Dee River watershed. Such surveys should also include the upper piedmont and coastal plain portions of the river. Additional information on the population status would help in formulating conservation strategies for both species in the Yadkin-Pee Dee River system.

Broad River, South Carolina Aquatic Resource Inventory Summary – Ross Self, SC DNR

The following summarizes and excerpts the *Broad River Aquatic Resources Inventory Annual Progress Report* (F-63-6) prepared by Jason Bettinger, John Crane, and James Bulak with the South Carolina Department of Natural Resources and the Federal Aid Annual Performance.

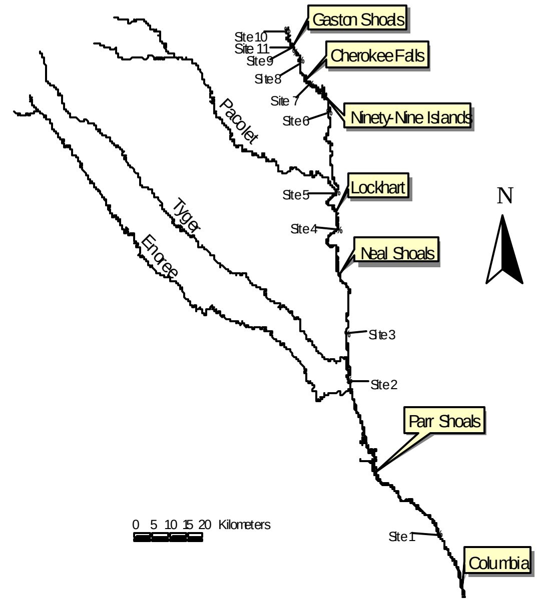
The Broad River, South Carolina flows approximately 100 miles across the South Carolina Piedmont to its confluence with the Saluda River. Along its run the Broad is impounded 7 times. All impoundments are relatively small and have run-of-the-river hydroelectric operations. The relicensing of these hydroelectric operations has led to the establishment of the Comprehensive Entrainment Mitigation and Fishery Resource Enhancement Program. This program is supported with funds provided by the utilities along the river (Duke Power, South Carolina Electric and Gas, and Lockhart Power). The first 3 years of funding from this program has been targeted toward an inventory of the resource.

STATUS SURVEYS



The Broad River fish community was surveyed during the fall of 2000, winter of 2001, and spring of 2001 at 11 sample areas along the course of the river (Figure 13). Fish were collected with boat and backpack electrofishing gear. Boat electrofishing was conducted in pool/run habitat and backpack electrofishing was used in complex habitat areas associated with shoals and islands. Over 350 transect samples were collected. To assess age and growth structure of representative species, otoliths or spines were collected from black bass (*Micropterus species)*, redbreast sunfish (*Lepomis auritus)*, redear sunfish (*Lepomis microlophus)*, channel catfish (*Ictalurus punctatus)*, and silver redhorse (*Moxostoma anisurum)*.

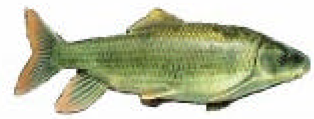
Figure 13. Broad River fisheries inventory.



Forty-three species of fish representing 9 families were collected from the Broad River (Table 4). Thirty-seven species of fish were collected with boat electrofishing gear; backpack electrofishing gear collected 27 similar species and 6 additional species. The family Cyprinidae contributed the most species (11) followed by Centrarchidae (9 species) and Catostomidae (8 species). Overall, the most common fish collected were redbreast sunfish, whitefin shiner (*Cyprinella nivea)*, and silver redhorse.

Table 4. Fish species collected from the Broad River, fall 2000 and spring 2001.

Common Name	Scientific Name	Family
White sucker	Catostomus commersoni	Catostomidae
Northern hogsucker	Hypentelium nigricans	Catostomidae
Smallmouth buffalo	Ictiobus bubalus	Catostomidae
Silver redhorse	Moxostoma anisurum	Catostomidae
V-lip redhorse	Moxostoma pappillosum	Catostomidae
Shorthead redhorse	Moxostoma macrolepidotum	Catostomidae
Brassy jumprock	Scartomyzon robustus	Catostomidae
Striped jumprock	Scartomyzon rupiscartes	Catostomidae
Redbreast sunfish	Lepomis auritus	Centrarchidae
Green sunfish	Lepomis cyanellus	Centrarchidae
Pumpkinseed	Lepomis gibbosus	Centrarchidae
Warmouth	Lepomis gulosus	Centrarchidae
Bluegill	Lepomis macrochirus	Centrarchidae
Redear sunfish	Lepomis microlophus	Centrarchidae



Smallmouth bass	Micropterus dolomieu	Centrarchidae
Largemouth bass	Micropterus salmoides	Centrarchidae
Black crappie	Pomoxis nigromaculatus	Centrarchidae
Gizzard shad	Dorosoma cepedianum	Clupeidae
Rosyside dace	Clinostomus funduloides	Cyprinidae
Greenfin shiner	Cyprinella chloristia	Cyprinidae
Whitefin shiner	Cyprinella nivea	Cyprinidae
Fieryblack shiner	Cyprinella pyrrhomelas	Cyprinidae
Common carp	Cyprinus carpio	Cyprinidae
Eastern silvery minnow	Hybognathus regius	Cyprinidae
Thicklip chub	Hybopsis labrosa	Cyprinidae
Bluehead chub	Nocomis leptocephalus	Cyprinidae
Spottail shiner	Notropis hudsonius	Cyprinidae
Yellowfin shiner	Notropis lutipinnis	Cyprinidae
Sandbar shiner	Notropis scepticus	Cyprinidae
Snail bullhead	Ameiurus brunneus	Ictaluridae
White catfish	Ameiurus catus	Ictaluridae
Flat bullhead	Ameiurus platycephalus	Ictaluridae
Channel catfish	Ictalurus punctatus	Ictaluridae
Margined madtom	Noturus insignis	Ictaluridae
Longnose gar	Lepisosteus osseus	Lepisosteidae
White Perch	Morone americana	Moronidae
White bass	Morone chrysops	Moronidae
Fantail darter	Etheostoma flabellare	Percidae
Tessellated darter	Etheostoma olmstedi	Percidae
Seagreen darter	Etheostoma thalassinum	Percidae
Yellow perch	Perca flavescens	Percidae
Piedmont darter	Percina crassa	Percidae
Eastern mosquitofish	Gambusia holbrooki	Poeciliidae

No federally listed threatened or endangered species were collected. The relative abundance of sucker species collected by gear type appears in Tables 5 and 6.

Table 5. Sucker species relative abundance (RA) for the fall, 2000 and spring, 2001 Broad River backpack electrofishing samples.

	Fall		Spring		Grand Total	
Common Name	No.	RA	No.	RA	No.	RA
Northern hogsucker	17	1%	10	1%	27	1%
V-lip redhorse	6	0%		0%	6	0%
Shorthead redhorse		0%	1	0%	1	0%
Brassy jumprock	14	1%	2	0%	16	0%
Striped jumprock	34	1%	25	1%	59	1%

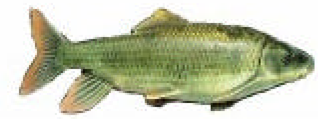


Table 6. Sucker species relative abundance (RA) for the winter, 2001 and spring, 2001 Broad River boat electrofishing samples.

	Winter		Spring		Grand Total	
Common Name	No.	RA	No.	RA	No.	RA
White sucker	1	0%	3	0%	4	0%
Northern hogsucker	5	1%	11	1%	16	1%
Smallmouth buffalo	2	0%	12	1%	14	1%
Silver redhorse	169	19%	222	13%	391	15%
V-lip redhorse	4	0%	3	0%	7	0%
Shorthead redhorse	11	1%	13	1%	24	1%
Brassy jumprock	59	7%	87	5%	146	6%
Striped jumprock	2	0%	29	2%	29	1%

The right pectoral spine was collected from 31 channel catfish. Otoliths from 536 fish were collected: 275 redbreast sunfish, 115 largemouth bass (*Micropterus salmoides)*, 59 redear sunfish, 47 silver redhorse, and 40 smallmouth bass (*Micropterus dolomieu)*. Data was also collected on the relative occurrence of substrate types and are presented in Table 7.

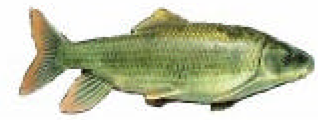
Table 7. Percent contribution of each substrate type, average depth, and average flow for each area sampled with backpack electrofishing gear during 2000 and 2001.

			Substrate Type					
Area	Sand	Gravel	Pebble	Cobble	Boulder	Bedrock	Depth (cm)	Flow (ft/s)
1	34%	26%	12%	11%	7%	9%	49	1.53
2	32%	24%	11%	11%	10%	12%	44	1.42
3	25%	8%	20%	6%	9%	32%	42	1.19
4	35%	9%	19%	9%	15%	13%	32	1.34
6	9%	13%	39%	19%	3%	18%	32	
7	11%	24%	32%	2%	2%	29%	41	1.42
8	11%	1%	5%	8%	20%	56%	48	1.28
9	17%	11%	30%	16%	7%	20%	33	1.28
11							46	
Overall Mean	21.7%	15.9%	21.5%	10.3%	8.3%	22.2%	41	1.35

Substrate components for visual assessment.

Particle type	Diameter	Value
Bedrock		8
Boulder	>256 mm	7
Coble	65 – 256 mm	6
Pebble	17 – 64 mm	5
Gravel	2 – 16 mm	4
Sand	0.06 – 2 mm	3
Silt	0.004 – 0.06	2
Clay	<0.004	1

S T A T U S S U R V E Y S



Lower Ocmulgee River, Georgia 2001 – Jimmy Evans, GA DNR

Background

Surveys for robust redhorse populations have been conducted throughout the historic range since 1998. During 1998 - 2000, surveys were conducted in Georgia on the following rivers.

- Upper Ocmulgee, from Lloyd Shoals Dam to Hawkinsville.
- Ogeechee, targeted sampling from Louisville to downstream of Millen. Additional sampling from Louisville to estuary conducted as part of GA DNR's annual standardized sampling program.
- Savannah, at Augusta Shoals and immediately below the New Savannah River Bluff Lock and Dam. Additional sampling from New Savannah River Bluff Lock and Dam to estuary conducted as part of GA DNR's annual standardized sampling program.
- Upper Altamaha, except in upper sections, targeted sampling largely ineffective due to record low flows. Additional sampling from confluence of Oconee and Ocmulgee to estuary conducted as part of GA DNR's annual standardized sampling program.

A significant robust redhorse population was discovered in the Savannah River at Augusta Shoals and below the New Savannah River Bluff Lock and Dam. A small population was also found in the upper Ocmulgee River between Warner Robins and Hawkinsville.

Future river survey needs throughout the historic range were reprioritized at the 2000 RRCC Annual Meeting. The list for Georgia included the following streams or stream reaches.

- Lower Altamaha, Doctortown to estuary.
- Lower Oconee, Dublin to confluence with the Ocmulgee.
- Lower Ocmulgee, Hawkinsville to confluence with the Oconee.
- Savannah above Port Wentworth.
- Broad River of Georgia.
- Briar Creek.

Due to prevailing flow conditions and logistics, the lower Ocmulgee (Figure 14) was chosen for sampling in 2001.

S T A T U S   S U R V E Y S

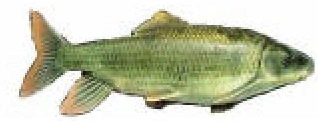
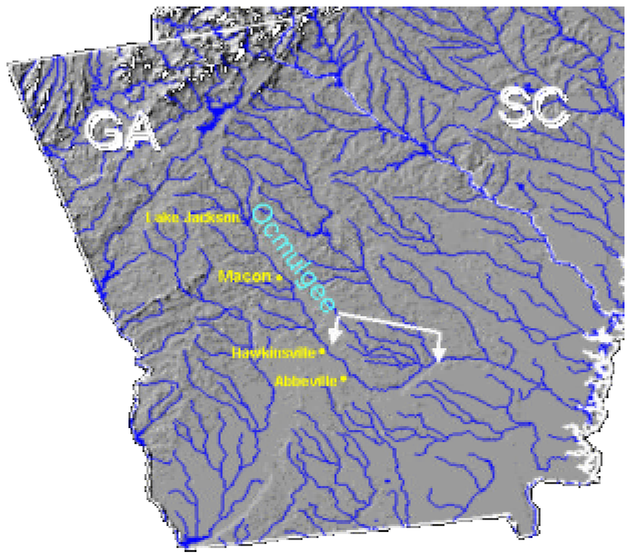


Figure 14. Ocmulgee River status survey, 2001.



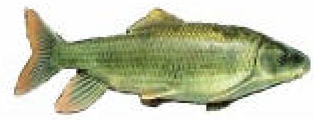
The primary objective of the status survey was to determine, with reasonable certainty, if a resident robust redhorse population exists in the lower Ocmulgee River between Hawkinsville and the confluence with the Oconee River. If one or more specimens were collected, additional knowledge could be gained from the location and life stage and from a determination of whether the specimen is an untagged fish, a tagged adult from the Oconee River, or a stocked juvenile from the Oconee or Ocmulgee rivers. A second objective was to determine if there is any migration from the Oconee and upper Ocmulgee rivers into the lower Ocmulgee. This migration, if it occurs, could be of either wild spawned adults or juveniles, or hatchery reared juveniles that have been stocked into the upper Ocmulgee and Oconee rivers.

Description of the Study Area

The Ocmulgee River within the study area is a medium size upper coastal plain river averaging 150 – 200 feet in width. Substrate is almost entirely sand with a few widely scattered bedrock and boulder outcrops as well as intermittent cobble and gravel deposits. The characteristic gravel deposits that are a requirement of the species are more limited than in the upper Ocmulgee and Oconee rivers. Prior to initiation of the survey, only 1 fairly extensive gravel deposit was identified about 1 mile below Barr's Bluff Landing near RM 41 (downstream of Highway 441). During the investigation other small deposits were located but they are probably unsuitable as spawning substrate due to combinations of small particle size, shallow deposition depth, and poor velocity distributions.

Several bedrock shoals are found within the study reach; the most extensive are in the area of Statham's Shoals. The only other notable substrate features are the limestone/sandstone deposits known locally as Altamaha grit. This material forms ledges that can erode into cobble and occasionally gravel-size deposits. Although the material is probably much less suitable than gravel as spawning substrate, areas near these deposits were sampled thoroughly. Altamaha grit deposits are scattered just above and below Statham Shoals, above and below Rocky Hammock, and one-half way between the Burkett's Ferry and Telfair County landings.

Robust redhorse are cover oriented and, except when concentrated around gravel deposits during the spawning phase, they are most often collected in outside meander bends adjacent to accumulations of woody debris. They are typically associated with moderate to swift current and



are rarely found in slack water or sluggish current. Macrohabitat features characteristic of the non-spawning life stage of the species are common within the lower Ocmulgee River study area, especially in meander sections. Although preferred robust redhorse habitat was selectively sampled more intensely during this survey, all habitat types received some electrofishing effort.

Results

The lower Ocmulgee River from Hawkinsville to Lumber City was sampled on eight dates from 30 June to 27 September 2001 (Table 8). Total electrofishing effort for the 2 crews was 23.3 hours and effort on individual days varied from 1.7 to 3.9 hours. Approximately 75% of the 123-mile target reach received some electrofishing effort. No robust redhorse were observed.

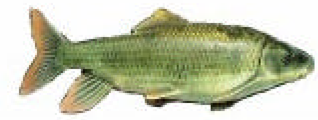
Table 8. Results of robust redhorse status survey on the lower Ocmulgee River between Hawkinsville and the confluence with the Oconee River, June – September 2001.

Sampling Area	River Miles	Sampling Dates (2001)	Electrofishing Effort (Hrs.)	Robust Redhorse Observed	Sampling Crew
Lumber City to lower boundary of Horse Crk. WMA	19	22 Aug 23 Aug	4.3 (2 day total)	None	Georgia Coop. Unit Georgia Coop. Unit
Lower boundary Horse Crk. WMA to Hwy 441	15	30 Jun 10 Aug	3.9 2.8	None None	GA DNR GA DNR
Red Bluff (Wilcox/Ben Hill Cty. line) to Abbeville	20	15 Aug 22 Aug	3.5 3.5	None None	GA DNR GA DNR
Abbeville to Pulaski/Dodge Cty. Line	17	27 Sep	1.7	None	GA DNR
Pulaski/Dodge Cty. line to Hawkinsville	20	10 Sept	3.6	None	GA DNR
Totals	**91**	**-**	**23.3**	**None**	-

Conclusions

Past experience with robust redhorse surveys on the Savannah, Ogeechee, upper Ocmulgee, and Pee Dee rivers has shown that 20 – 30 hours of electrofishing effort by experienced crews under good sampling conditions is sufficient to detect the presence of the species in small to medium size rivers. All of these conditions were met during the lower Ocmulgee River survey. Although 25% of the reach remains to be sampled, results of sampling to date suggests that a resident, adult robust redhorse population probably does not exist downstream of Hawkinsville. Observations of habitat preference in the Oconee, upper Ocmulgee, and Savannah rivers indicate that suitable, clean gravel spawning substrate, in association with characteristic depth and current velocity distributions, is closely correlated with the presence of the species. This combination of habitat features was extremely rare within the lower Ocmulgee River study reach.

With the conclusion of the sampling in 2001, most of the 241 RM length of the Ocmulgee River between Lloyd Shoals Dam and the confluence with the Oconee River has been surveyed



specifically for robust redhorse. The upper Ocmulgee River from Lloyd Shoals Dam to Hawkinsville was sampled for 3 days with 6 electrofishing boats in June and October 1999. Two natural spawned and 2 stocked juveniles were collected with an accumulated electrofishing effort of 26.4 hours. All of these fish were collected within a short reach between Warner Robins and Hawkinsville and it now appears that a single 30 – 40 RM section may contain the only population of robust redhorse in the Ocmulgee River. It should be noted that this reach is physiographically similar to the section of the Oconee River between Milledgeville and Dublin that contains the largest known population of robust redhorse. Little is known about the status of the robust redhorse in the upper Ocmulgee River, although it appears to be much less abundant than in the Oconee.

Discussion Points

There has been some surveying done on the river below Highway 441. There does not seem to be gravel spawning beds in the lower part. However, there are sections of the river that still need to be looked at more closely.

Status Surveys Priorities for 2002

In discussing status survey priorities, documented policies or long-term plans was identified as a need to prevent a disjointed approach in setting annual priorities. A thoughtful approach might include developing a list of promising stream characteristics and setting priorities for new surveys based upon those characteristics. The goals in the conservation strategy might inform this approach as well.

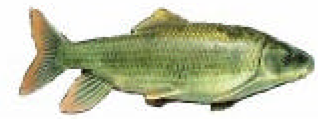
The following presents the RRCC’s thoughts on surveys for 2002. Each set represents an approximate order of priorities.

Survey priorities for North Carolina

- The same two reaches of the Pee Dee River surveyed in 2001.
- A stretch of river above High Rock Lake.
- Spawning and adult holding areas in the upper coastal plain.
- The Rocky River.
- Tributaries below the Blewett Dam.

Survey priorities for South Carolina

- Continue on the mainstem of the Broad, including the lower stretches below Columbia.
- Use additional federal funds to expand the search into tributaries.
- Catawba River.
- Meander bends downstream of Cheraw.
- Upper Lynches River.

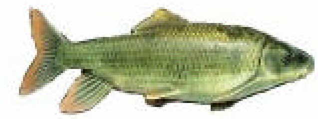


- The Edisto will not be surveyed since it does not have access to enough Piedmont.

Survey priorities for Georgia

- The lower Oconee from the confluence to Dublin.
- A low water survey of the Savannah River for gravel beds from Steel Creek north to the New Savannah Bluff Dam.
- The lower part of Brier Creek.
- The Altamaha River.

G E N E T I C S



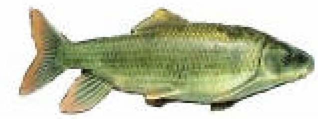
Razorback Sucker Genetics Management and Captive Propagation Program, Dexter National Fish Hatchery and Technology Center, NM – Holt Williamson, USFWS

The Management Problem

The razorback sucker (*Xyruachen texanus)* is a large river catostomid fish endemic to the Colorado River basin and its larger tributaries. It is one among several native large river fishes listed as endangered by the USFWS that require protection under the Endangered Species Act of 1973. The razorback sucker has declined in distribution and abundance since construction of various water development projects initiated throughout the basin beginning in the early part of the twentieth century and continuing to the present. Threats to the species are associated primarily with loss of spawning and rearing habitat and restricted fish movement caused by construction of mainstem dams for flood control, recreation, and power generation to growing metropolitan centers. Agricultural projects throughout the basin have also been associated with razorback sucker decline due to dewatering of rivers and streams for crop irrigation and construction of levees preventing seasonal flooding and access of young razorback sucker to offstream nursery areas. Introduction of numerous nonnative fishes into these altered environments has resulted in established fish populations that prey on razorback sucker and compete with them for food, habitat, and mates. The result of these ecological perturbations is environmental change that has adversely affected the long-term viability and sustainability of razorback sucker within their native habitat. Unless management intervention is initiated, aimed at protection and recovery, the prognosis for razorback sucker is extinction throughout its natural range.

The largest and most genetically diverse aggregation of razorback sucker remaining in the Colorado River basin is in Lake Mohave, a mainstem Colorado River reservoir, the geographic boundaries of which are confined between Hoover Dam upstream and Parker Dam downstream and the ecological characteristics of which are determined by dam operations. Thus, the Lake Mohave razorback sucker population is essentially a captive population. The Lake Mohave razorback sucker population consists of a declining number of old adults (estimated to be at least 50 years of age). Adult population estimates have ranged from 60,000 individuals in the 1980s to fewer than 10,000 today. Fish continue to spawn at particular sites within the reservoir every year, fry emerge but the young are not recruited. Indeed recruitment failure has defined the population since the reservoir was impounded. Unless management actions are taken to offset the loss of old adults with new recruits, the Lake Mohave razorback sucker population and its unique genetic resources will soon perish. Some managers view the Lake Mohave razorback sucker population as the primary source for genetic material needed to recover the species throughout the Colorado River basin. They give it the highest priority ranking among other razorback sucker genetic conservation units in the overall razorback sucker recovery effort. Loss of the Lake Mohave razorback sucker population will have severe consequences for the existence of the species as a whole.

GENETICS



Conservation Goals and Conservation Strategy

Immediate conservation goals for razorback sucker in Lake Mohave are to avert extirpation of the population and to conserve its genetic resources. The management scenario presented by status and trend assessments and goals suggests that the Lake Mohave razorback sucker population is viewed as an *in situ* artificial genetic refuge population. The population is viewed as *in situ* because the target species is maintained within its, more or less, natural habitat but artificial in that Lake Mohave is an intensively managed reservoir. In this instance, however, more intensive management is required for long-term maintenance of the razorback sucker population in the reservoir. Controlled propagation in designated facilities and fish reintroduction is an appropriate production strategy or approach to prevent imminent loss of the razorback sucker population in Lake Mohave. Currently fisheries managers are capturing wild larvae as they emerge from spawning sites in the reservoir and transporting them to Willow Beach NFH, Arizona, a hatchery facility adjacent to the reservoir, where the young fish are reared until large enough to mark and stock back into the reservoir to replace aging adults. Mark and recapture information indicates there is some survival of hatchery reared and stocked razorback sucker in Lake Mohave. Whether hatchery reared razorback sucker will recruit in sufficient numbers as effective breeders before the disappearance of the old natural population is not known. The management objective is to reach and maintain through the captive propagation/reintroduction strategy a razorback sucker population in Lake Mohave of 50,000 adults.

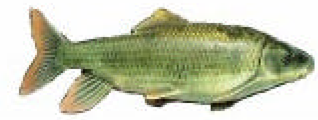
Dexter's Program Purpose and Perspective

Dexter NFH and FTC, New Mexico has played the major role in protecting the Lake Mohave razorback sucker population with its abundant genetics resources for over 20 years. It is now playing a supporting and complementary role in the broader captive propagation strategy for Lake Mohave razorback sucker described above. Dexter's program is designed to avert imminent population extinction, conserve genetic resources, and, when defined by management, to produce razorback sucker that are needed in recovery efforts for the species. Dexter's captive propagation approach is based on a gene pool conservation program designed, implemented, and evaluated from a genetic conservation perspective. Dexter's genetics management goals and captive propagation objectives are as follows:

1. Develop and maintain a Lake Mohave razorback sucker *ex situ* artificial genetic refuge (AGR) population with an effective population size of 200 mature breeders over ten years.

2. Supplement Dexter's original Lake Mohave razorback sucker captive production broodstock (CPB) with additional genetic material from the original donor source, Lake Mohave.

3. Produce razorback sucker offspring of known genetic quality and in sufficient number and size consistent with recovery, research, and other approved management needs defined for the lower Colorado River basin.



4. Cryopreserve Lake Mohave razorback sucker sperm.

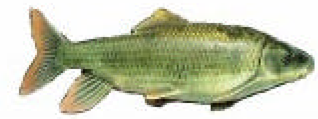
5. Develop a captive propagation program integrating genetics, performance, management, and environmental components geared toward product development and based on established standards of excellence.

6. Develop a comprehensive, holistic, and integrated research and technology development program to complement and improve Dexter's razorback sucker captive propagation program.

Genetics Hazard and Risk Management System

Dexter's captive propagation strategy (the program, plan, and process) is engineered and employed within a genetics hazard and risk management (GHRM) system. The GHRM system or conceptual framework is relied on to guide the captive propagation planning, process, and operations. The understanding and use of basic evolutionary theory, genetics principles, and a common language is based upon relevant theory and principles. The working vocabulary is shared among scientists and managers and is necessary to avoid the errors born of confusion and frustration resulting from poor communication. For example, all genetic changes are known to be due to specific evolutionary phenomena: mutation, migration, drift, selection, and nonrandom mating. But, more importantly, this knowledge is applied in communicating with experts and peers and in planning, implementing, and evaluating the program. The use of the GHRM system also relies on an understanding and application of concepts of hazard and risk management. For example, the fundamental genetic hazard associated with captive propagation within a gene pool maintenance program is loss or undesired changes in the genetic variation or identity of the founder population with respect to its donor source.

Genetic losses or changes are due to several fundamental processes that occur everywhere - in the river or on the hatchery. For example, total loss of genetic diversity is due to species or population extinction. All genetic resources within a fish population can be lost on a captive propagation facility due to some catastrophic event - lost power, no water, complete mortality. Of lesser magnitude, but a serious hazard nevertheless, is loss of within population diversity due to the effects of genetic drift, a common event associated with maintaining small captive populations. Another process leading to altered genetic structure in small populations is inbreeding, or the mating of related individuals. Loss of population diversity or loss of population identity occurs on a captive propagation hatchery when different populations are mixed and interbreeding occurs. Finally, genetic variation of captive populations can be lost on a hatchery when the populations adapt to the hatchery environment, a process called inadvertent or domestication selection. Domestication is thought to result in genetic changes that affect the fitness of a population. The broodstock manager can reduce the risk of genetic hazards or losses resulting from these natural processes through insightful and skillful manipulation of the system's essential components during the broodstock management process. GHRM system components are the (1) sources of genetic hazards inherent in any management activity, (2) proximate



management safeguards (decisions, actions, or mechanisms) that are employed to reliably reduce the risks associated with necessary management activities, (3) endpoints or critical nodes in the management process where genetic losses are most likely to occur, (4) ultimate management safeguards or mechanisms that are employed to permit recovery from the occurrence of genetic losses, and (5) some estimate or assessment of the particular risk involved.

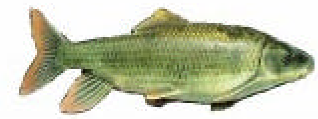
Dexter’s Basic Captive Propagation Strategy and Process

Dexter’s basic strategy to propagate and manage its captive razorback sucker populations is application of the GHRM system throughout the broodstock management process. Effective GHRM application depends on the broodstock manager knowing and understanding fundamental evolutionary theory and genetics principles then, translating them into a working vocabulary common both to geneticists and fisheries managers, and employing the concepts operationally. With this strategy, routine hatchery practices are acknowledged as necessary yet are recognized as potential sources of genetic hazards that must be managed to reduce the risk to the broodstock of their undesirable or hazardous genetic effects. These genetic hazards are defined as lost genetic variation or altered performance for population characteristics with a heritable component. Once again, applying the GHRM system during all broodstock management process steps is crucial. Process steps required of the broodstock manager are (1) orienting and locating within the management environment; (2) problem analysis and goal development; (3) prioritization; (4) planning; (5) implementing; (6) monitoring and evaluating results in order to adapt the program, plan, and process for improved performance; and (7) product in terms of goals and objectives. Proper application of the GHRM system lies in identifying necessary captive propagation activities, assessing their potential for inducing genetic losses, and developing and using proximate genetic management safeguards that reliably reduce genetic risks associated with routine breeding and rearing activities.

Broodstock Management Issues and Activities

The basic approach to captively propagating and maintaining Lake Mohave razorback sucker at Dexter focuses on genetics, fish performance, management, and environmental issues and the basic management activities wherein genetic hazards reside. The basic management activities of broodstock development and management are (1) selection of the proper donor source, (2) collecting wild fish or gametes, (3) choosing and applying the proper breeding or mating system, (4) rearing broodfish to maturity, and (5) rearing young for various management activities. With respect to genetics, the Lake Mohave razorback sucker population has been identified as the highest priority genetics conservation unit (GCU) in the lower basin in terms of its ultimate value to species identity and integrity, its recovery, and its long-term viability and sustainability.

The Lake Mohave population has been selected as the proper donor source upon which to found the *ex situ* AGR and captive production broodstock populations. The wild adults are collected in a manner that reduces the risk of genetic losses associated with nonrandom sampling and small sample size. Wild adults are retained only for the time it takes to spawn them. Then the marked adult is returned to the reservoir thereby little impacting the genetic and demographic health of

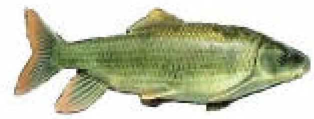


the wild lake population. The adults are bred in a manner that maximizes effective population size of the captive parental population (mating as many unrelated adults as possible using a factorial mating scheme, in particular, a pedigree mating scheme). In terms of management activities and the culture environment, the offspring are incubated and reared to maturity in a manner that maximizes effective population size of the parents while reducing the effects of selection on offspring (maintaining family lot integrity until individuals can be marked by family, and rearing offspring to minimize unintentional mortality while purposefully reducing among families). When needed, Dexter will produce fish for reintroduction that reflect accurately the genetic identity of both the donor and captive populations. The aforementioned activities are conducted using a variety of proximate genetic management safeguards that promote management success while reducing the risk of genetic hazards inherent in all captive breeding programs.

Program Evaluation with Respect to Goals

In terms of goals and objectives achieved since 1995, when Dexter's genetics conservation and captive propagation program was initiated for Lake Mohave razorback sucker, some important successes were experienced. There is now a first generation *ex situ* artificial genetic refuge population (although not all year classes have reached maturity) based on over 160 wild, unrelated razorback sucker adults (83 family lots). Although the aging adult population in the reservoir continues to decline, the stated goal of a first generation *ex situ* artificial genetic refuge population based on 200 wild, unrelated adults is still expected to be reached. If managed properly, they represent the Lake Mohave donor population with an effective breeding size of 400 individuals. This same captive population, when needed and fish are mature, can be used to genetically augment Dexter's original Lake Mohave broodstock (1981 yc). By so doing a captive production broodstock has been developed that can provide razorback sucker offspring for a variety of management and recovery activities where the Lake Mohave genotype is desirable. Further, basic methods to freeze razorback sucker sperm have been developed for long-term genetic conservation purposes and gamete extension technology to enhance the effectiveness of breeding schemes. In-house capability for genetic analysis of founders, broodfish, and offspring has been developed, which will increase the reliability and timeliness of genetics data necessary for effective management. In particular, the genetics data will be usable to evaluate the success of the basic captive propagation strategy, the proximate genetic management safeguards, and the procedures, practices, and protocols. However, at this time those genetics data have yet to be generated. Nor have we been entirely successful in developing a comprehensive captive propagation program integrating all elements (genetics, fish performance, management, and environmental). Neither have we been as successful as we would desire in creating and integrating a complementary research and technology development component into the overall captive propagation program. However, these are long-term goals and progress in the right direction has been steady.

The successes are limited as well by other unforeseen constraints of various sources, some within our domain of control and others not. In addition to genetics baseline data, a method of marking small fish (less than 100 mm TL), at least by family origin, is needed. Although the PIT tag is the



foundation of the controlled breeding program, each tag is expensive and can be used only in larger fish. An economical family mark would expedite the development of additional family lots and increase the efficient use of facilities and financial resources. In addition, such a marking system would help answer questions and determine relationships of genetics and fish performance on the hatchery and following stocking in the wild. Better fish culture methods and rearing environments to improve fish performance on the hatchery and perhaps following stocking are needed. At this time under current hatchery conditions unacceptable levels of mortality and physical abnormalities are being experienced.

Prognosis and Plan for 2002-2006

All signs indicate that the Lake Mohave razorback sucker will continue to decline in the reservoir and unsupported natural recruitment will be extirpated within ten years. In principle, the goals for the next five years will remain the same as those in the original plan but we hope to increase the total number of family lots produced and accelerate the rate of production. Future efforts will focus on overcoming constraints impacting our success. Ultimately, we plan to expand and improve our results through better management (e.g., more effective employment of proximate genetic management safeguards). In particular, we anticipate generation and use of genetics data in the laboratory; we plan to develop a system to identify young fish by family lot; and we plan to develop fish culture methods and rearing systems that increase survival and improve fish performance. Although uncertain at this time, the cryopreservation program should be restored. We also plan to better integrate our efforts with other ongoing captive propagation programs for razorback sucker in both the upper and lower Colorado River basins. We anticipate the improvements within our program and better integration with other recovery efforts will have a greater beneficial effect on razorback sucker and expedite their sustainable recovery. *Nine Basic Lessons Learned by a Captive Broodstock Manager* can be found in Attachment 2.

Discussion Points

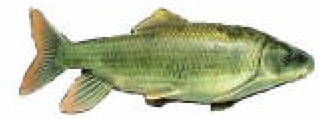
The program has not had the money to mark individual families of the razorback sucker as a measure of reproductive effectiveness. Reproductive success of males and females at the time of fertilizations is noted but we are not tagging by family so cannot estimate reproductive gender success.

In the upper basin where there are fewer fish, our efforts have focused on getting more cross breeding. In the lower basin where there are more fish, we can do pair breeding, keep families separate and tag them.

I would guess the declining stocks of fish in the lower basin are due to habitat loss. The shoals are all lost in the reservoirs. The tiny larvae are probably being eaten and/or are not getting enough to eat.

Electro-fishing for this species if fairly easy, we shock and they float to the surface where they can be lifted out of still water. In swifter currents, they will float off and can be hard to retrieve.

GENETICS



Molecular Approach to Identify Robust Redhorse Larvae – Diane Currie and Isaac Wirgin, NYU

Indices of abundances of larval stages of robust redhorse are needed to identify environmental factors, which determine early life stage success. Morphological and ecological characteristics that unequivocally distinguish larvae of redhorse species are currently lacking. Analysis of DNA permits investigations from even the smallest life stages of fish by using the polymerase chain reaction (PCR). PCR also permits the analysis of large numbers of samples frequently needed to address questions of ecological concern. Mitochondrial DNA (mtDNA) offers the advantage, that because it is maternally inherited, all progeny of a single female share identical mtDNA haplotypes.

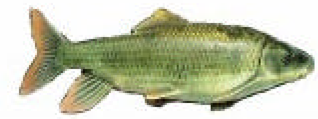
The mtDNA control region of silver redhorse and robust redhorse were screened using sequence analysis for polymorphisms between the two species. Two polymorphic nucleotide sites were detected that exhibited differences between DNA from a small number of adult silver and robust redhorse and that could be easily distinguished using restriction fragment length polymorphism analysis. Computer analysis of these mtDNA sequences indicated that two restriction enzymes, Hinf I and Ssp I, recognized these polymorphic nucleotide sites and could be used to distinguish the mtDNA of the two species. As expected, DNA isolated from 40 adult silver and robust redhorse, respectively, exhibited fixed differences at these two diagnostic restriction enzyme digest sites. Thus, the use of this assay was validated on substantial numbers of known samples. This assay was then applied to two groups of unknown larvae provided by UGA (n = 56 and n = 10). All larvae were unequivocally identified as silver redhorse. In summary, we developed an easy to use assay, which with 100% accuracy could be used routinely to distinguish larvae from these two species.

Discussion Points

In terms of applications for the field, the analysis described is easy to do as long as the samples are properly treated. The use of formalin to preserve samples makes DNA testing more difficult. DNA testing is easier to do if the samples are preserved in ethanol but a greater volume of ethanol must be used so that the sample is well preserved. The established protocol for sending samples to Dr. Wirgin for this testing should be followed.

Comparison of Mitochondrial DNA and Nuclear DNA Divergence in Robust and Silver Redhorse from the Oconee, Savannah, and Pee Dee Rivers – Isaac Wirgin, Diane Currie, Lorraine Maceda, NYU and Joseph Stabile, Department of Biology, Iona College

This study compared the extent of genetic divergence between robust redhorse from the Oconee, Savannah, and Pee Dee rivers to that in silver redhorse from the same rivers. The overall objective was to evaluate the taxonomic importance of genetic differences previously reported in mtDNA sequences among robust redhorse from these 3 populations. Mitochondrial DNA control



region sequence and microsatellite analyses of nuclear DNA (nDNA) were used to quantify genetic differences among these robust redhorse and silver redhorse populations.

All robust redhorse from the Oconee River (n = 47) exhibited 2 mtDNA haplotypes (A and B) that were absent in robust redhorse from the other 2 populations. Similarly, robust redhorse from the Savannah River (n = 27) exhibited 3 mtDNA haplotypes (C, D, and D') that were absent in robust redhorse from elsewhere. Finally, robust redhorse from the Pee Dee River exhibited mtDNA haplotypes (E and E') that were only seen in that river. Overall mtDNA sequence divergence between robust redhorse from the Oconee and Savannah rivers averaged about 1.0%. In comparison, the 2 robust redhorse collected from the Pee Dee River in the years 2000 and 2001 exhibited much more genetic divergence from robust redhorse from the other 2 rivers (3%).

Mitochondrial DNA control region sequence analysis was also conducted on silver redhorse from these same rivers. Congruent results were obtained to those for robust redhorse with several exceptions. Most but not all fish (17/19) from the Savannah River exhibited mtDNA haplotypes that were absent in fish from the Oconee (n = 20) or Pee Dee (n = 12) rivers. However, the extent of mtDNA sequence divergence among silver redhorse from these rivers was not as pronounced as that seen with robust redhorse. Pee Dee River silver redhorse were once again most divergent but the extent of genetic divergence between fish from the Pee Dee and other rivers was only 1.0% compared to 3% for robust redhorse.

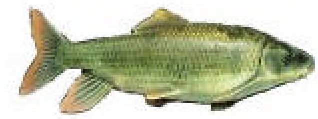
Nuclear DNA analysis was conducted on the same robust redhorse and silver redhorse samples described above using microsatellite primer sets developed from a robust redhorse library. Fixed nDNA allelic differences were observed among robust redhorse from these 3 populations at a single locus and highly significant ($P < 0.01$) allelic frequency differences were observed at 5/6 of the remaining loci. At the RR37 locus, no overlap in molecular size was observed among robust redhorse from the 3 populations highlighting the number of mutational steps between fish from the 3 populations and the extent of their nDNA divergence. We proceeded to use microsatellite analysis at 3 of these loci on silver redhorse from these 3 populations. Our results revealed highly significant allelic frequency differences among all populations but an absence of fixed differences. In summary, our results indicate that populations of both robust redhorse and silver redhorse in coastal Piedmont Rivers are highly genetically distinct in both their mitochondrial and nuclear genomes. However, the magnitude of genetic differences among robust redhorse populations exceeds that among silver redhorse populations suggesting that robust redhorse populations may warrant additional protection as evolutionary significant units.

Discussion Points

It is not clear when we should stop managing the populations and start managing the species based on very few numbers of individuals within a population. At some point someone has to make the call that the risk of genetic inbreeding has become too great.

The issues involved with managing the populations or the species include:

G E N E T I C S



- There are 3 distinct populations of robust redhorse. The population that has been found in the Pee Dee River may not be genetically diverse. The fixed differences in mtDNA among the drainages, suggests the Pee Dee River population became genetically divergent from the Savannah and Oconee rivers fish about 1.5 million years ago, while the Savannah and Oconee rivers fish became genetically divergent from each other about 0.5 millions years ago.

- A single population could show a gradient with gradual changes in haplotypes along the river. If samples are taken only from the upper and lower reaches of the river, one could believe there are 3 distinct populations because the middle of the gradient remains unseen.

- The robust redhorse has fairly high genetic diversity. We do not know if this fish has been through a genetic bottleneck. If the robust redhorse has just or is just now going through a bottleneck, it will take a few generations to show up in the microsatellite data. Given the age to which these fish live, it would take about 60 years to see the effects.

- The robust redhorse may have always been a rare fish or it may be only now becoming rare and moving to extinction. The 2 scenarios lead to different thoughts about how best to manage the species.

- The river redhorse is now seen in large numbers. The robust redhorse may have been quite common. We are only now emerging from a 150-year period of habitat degradation.

- Given that the robust redhorse only spawns on gravel and that these gravel beds are rare commodities on the coastal plain, we should manage the fish and manage the habitat.

Genetic Sensitivity Analysis of Robust Redhorse Supplemental Breeding Program – Anthony Fiumera, PSU

The maintenance of genetic diversity is often one of the many objectives in a supplemental breeding program. Maintaining genetic diversity is important to reduce the potential for inbreeding and to maximize the adaptive potential of the population. The effective population size (N_e) can be a useful index for the amount of diversity retained within a supplemental breeding program, and thus, estimates of N_e are often incorporated into management strategies.

This study estimates the effective population size of each of the 9 different year classes within the supplemental breeding program of the robust redhorse and makes predictions regarding the genetic impact to the natural population of stocking supplemental fish. The number of parents from each year class varied from 2 to 40 and the corresponding effective population sizes ranged from 0 (in 2 years with complete mortality) to 27 individuals (Table 9). A stocking program where each year class is represented in proportion to its effective population size will maximize the overall N_e at roughly 105 individuals.

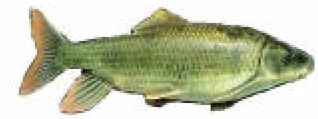


Table 9. The number of males and females, the effective population size and the relative stocking effort for each of the 9 different year classes within the supplemental breeding program of the robust redhorse.

Year	Males:Females	N_e	Relative stocking effort (%)
1993	1:1	2	2
1994	6:5	0 [1]	0
1995	16:16	22	21
1996	?	0 [1]	0
1997	16:11	23	22
1998	10: 5	8	7
1999	21:19	27	26
2000	28:12	20	19
2001	10: 2	4	3

[1] Realized due to near 100% mortality

The impact of stocking a given number of fish into the Oconee River can be predicted under a very restrictive set of assumptions. Ryman and Laikre (1991) identified the following assumptions: constant population size, discrete generations, and spawning in either the wild or the supplemental program (Conservation Biology 5:325-329). In addition, assuming the wild population is steady at 807 individuals with a wild N_e of 202, a generation time of 15 years and a captive N_e of 105, then stocking roughly 250 reproductive individuals (according to the relative stocking effort from Table 8) should minimize the genetic impact of stocking. The number to be stocked, however, is greatly influenced by the validity of the assumptions and changes by almost an order of magnitude (45 individuals) when there is a steady population of 1614, a wild N_e of 807, a generation time of 20 years and a captive N_e of 50 individuals. Although these estimates provide useful information on the potential impact of stocking, their interpretation is very sensitive to the validity of the assumptions and management decisions should therefore be made with caution.

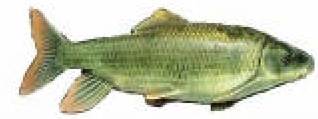
Discussion Points

The number to be stocked in a river would vary from year to year based on the success and failure of the year class. So, we might never stock more of a 1995 or earlier year class.

The model assumes that removal of the fish for N_e takes the fish completely out of the wild population census rate. Since the robust redhorse breeds for multiple years and may have bred before being captured, the actual events will deviate from the model. To be on the safe side, the number of fish to be stocked in the river should be lower to compensate.

A census of the spawn-able adults is desired. The theory says that the effective size is about one half of the census. However, the robust redhorse is very fecund, so the effective size could be as low as 10%. An effective size of 25% has been used in this study.

G E N E T I C S



The estimates derived from the modeling are very much affected by the assumptions that are made about discrete generations and population stability. If the population is declining, the goals may shift.

Reducing the census size to the effective size takes into account such factors as one third to one half of the males on the spawning grounds not mating.

We may be dealing with zero recruitment in which the 800 fish out there are not replacing themselves and all of the fish will eventually die of old age. In this scenario, captive breeding becomes key. On the one hand we may want to stock as much as we can and on the other we may want to be careful and not to stock very much.

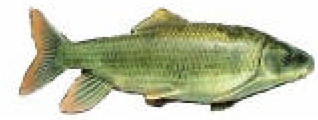
On the Oconee River there seems to be some recruitment, although at a very low rate. We simply do not know enough biology about this fish and so must make assumptions and the best estimates we can. As we learn more about this fish, we can better determine what to do to manage it.

Everything in the environment is in flux, so the assumptions in the model of a steady state are unsupportable. We cannot even agree about whether the environment is getting better or getting worse. We can only agree that it is changing.

The population estimate modeling indicated that the fish would likely last for another 2 or 3 generations, not necessarily for another 100 years. The model was clear that the fish would not become extinct in the next 10 years.

The genetic sensitivity modeling is valuable because it clarifies the assumptions that are being made, which is critical for these discussions.

R E I N T R O D U C T I O N M A N A G E M E N T



Summary of Broad River, Georgia Re-introduction – Bud Freeman, UGA

A presentation summary on the re-introduction of the robust redhorse into the Broad River, Georgia was not submitted but meeting attendees recorded the following discussion points.

Flathead catfish are not common in the upper part of the Broad River watershed but can be found in the lower reaches of the river. The Broad River has extensive gravel that is suitable for spawning habitat and a lot of sand and silt.

Robust redhorse were observed in the river. Specimens and tags were not pulled. Surveys for gametes are conducted in the spring depending on time and money.

After the initial stocking, robust redhorse were found in the Savannah River below Augusta, so stocking of Oconee fish was ceased. It is uncertain if the robust redhorse stocked into the Broad River have traveled below the dam. In 1999 GA DNR picked up some Oconee River fish at the upper monitoring points below Clarks Hill. No one is monitoring near Russell. There are 4 dams between the Broad River and the population that was found in the Savannah River. It is possible that the fish have moved back into the Broad River or into other places that are not monitored.

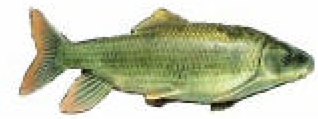
Update on the Robust Redhorse Conservation Strategy and the Consolidated Conservation Agreement with Assurances – Mike Nichols, GPC

The Conservation Strategy is the RRCC's overall conservation plan for the species throughout the historic range in Georgia, South Carolina, and North Carolina. The purpose of the Conservation Strategy is to (1) maintain direction and continuity for the RRCC, (2) assure continued survival of robust redhorse, (3) describe the status and distribution of the species, (4) review problems facing the robust redhorse, and (5) present goals and actions of the recovery effort.

The conservation strategy follows a set format. The introduction provides an update on the known and introduced populations and lists the current members of the RRCC. The status and distribution is discussed in the next section, which includes the status of adult refugial populations in ponds and population estimates for the known populations. The population estimate given for the Oconee River is up to 600 adult fish between Dublin, Georgia and Big Black Creek.

Problems facing the species are discussed in context to those requiring exploration under the Endangered Species Act. Resolution of potential problems facing the robust redhorse may include habitat restoration opportunities, experimental spawning substrate augmentation, and flathead catfish removal. The extent to which any of these recovery activities might be effective is unknown and not addressed in the conservation strategy.

REINTRODUCTION MANAGEMENT



Long- and short-term conservation goals for the robust redhorse are listed in the next section. The long-term goal for the species is to establish or maintain at least 6 self-sustaining populations distributed throughout the historic range. Short-term goals (2000 – 2005) include establishing refugial populations to reduce the impact of potential catastrophic events in the Oconee and Savannah rivers on species survival. This short-term goal will be achieved by establishing a list of candidate sites and a process for prioritizing sites using specific criteria, determining habitat and life history requirements, and establishing the necessary reintroduction plans or agreements to implement conservation actions for specific sites. Other short-term goals include locating other wild populations within the historic range; determining characteristics for viable populations including population size, genetic variability, recruitment rate, and mortality rate; and implementing the necessary actions to maintain the Oconee and Savannah river populations.

Conservation actions to support achieving the long- and short-term goals and objectives will be undertaken. These actions include managing artificial propagation from adult broodfish collected in the Oconee and Savannah rivers and implementing watershed management practices utilizing existing regulatory processes to protect suitable spawning sites from erosion and sedimentation.

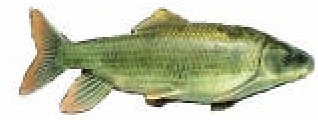
The conservation strategy also describes monitoring activities necessary to evaluate the status of the species and the success of the recovery effort and lists the primary RRCC partners responsible for undertaking each activity. Specific monitoring includes (1) assessing the age structure and mortality rate for the Oconee River population, (2) assessing the population present in the Savannah River, (3) assessing the possible existence of other spawning sites in the Oconee River, (4) monitoring survival and growth of juveniles introduced at other locations as described in applicable reintroduction plans or agreements, and (5) assessing the possible existence of other populations in other rivers in the historic range.

The conservation strategy is outdated in some areas, as recent work has revealed new information. The consensus of the RRCC was to update the conservation strategy by charging the TAG with providing Mike Nichols with comments and revisions. The updated conservation strategy will be presented to the RRCC at the 2002 Annual Meeting for adoption.

Within the framework of the conservation strategy, a Consolidated Conservation Agreement with Assurances (CCAA) has been drafted and is under final review. The CCAA is specific to recovery activities for the robust redhorse in a portion of the Ocmulgee River. Pending approval from the regional office of the USFWS, the CCAA could be scheduled for notice in the Federal Register the week of October 22, 2001.

Discussion Points

In preparing the CCAA, breeding areas in the Ocmulgee River above Juliette Dam have been investigated. There are 17 miles of rocky and gravel stretches in that area, which appears to be good to excellent spawning habitat.



Several year classes will be stocked at the same time to ensure good diversity in the Ocmulgee River. The Ocmulgee and Oconee rivers are linked at their confluence with the Altamaha River. Fish could travel from the Ocmulgee project reach into the Oconee. However, the upper Ocmulgee has some of the best spawning sites in the state. GPC and GA DNR will monitor events and modify stocking regimens if problems arise.

Robust Rehorse Restoration Proposal for the Broad River, SC – Ross Self, SC DNR

South Carolina Department of Natural Resources is developing a plan to reestablish a self-sustaining population of robust redhorse in the Broad River of South Carolina. The following summarizes the 3 major goals of the proposal, lists objectives for each goal and includes a schedule of activities to accomplish the goals and objectives.

The first goal is to generate support for the proposed reestablishment of a self-sustaining population of robust redhorse suckers in the Broad River. The corresponding objective is to develop a consensus of approval for the proposed action among aquatic resource interest groups.

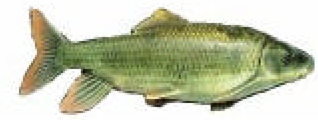
The second goal is to develop a hatchery production program for robust redhorse. The 3 associated objectives and schedules of activities include:

Objective: Develop a domesticated population of robust redhorse broodfish.
Schedule: 2001 – Rearing of existing fish now held by DNR.
2002 – Collection of wild brood stock and production of robust redhorse fingerlings. Continued rearing of existing hatchery specimen. Rearing of fish produced from wild- caught brood as future supplemental hatchery broodfish.
2003 – 2006 – Collection of additional wild brood stock while continued development of reared broodfish.

Objective: Conduct research studies as required enhancing the culture of captive robust redhorse.
Schedule: 2001 – Assignments of duties and responsibilities.
2002 – Identification and prioritization of research needs. Identification of funding and selection of research facilities and personnel. Implementation of identified research.
2003 – 2006 – Continued identification of research needs and funding sources. Publication of resultant findings and implementation of appropriate findings.

Objective: Produce robust redhorse for stocking into the Broad River.
Schedule: 2001 – Assignment of hatchery production space.
2002 – 2006 - Implementation of production based on stated needs. Evaluation of techniques and employ improvements as required.

REINTRODUCTION MANAGEMENT



The third program goal is to establish a self-sustaining population of robust redhorse suckers in the Broad River while limiting or preventing negative effects on native fish populations. The associated objectives and scheduled activities include:

Objective: Stock the Broad River with robust redhorse suckers in numbers sufficient to establish a self-sustaining population.
Schedule: 2001 – Development of stocking rates and schedules.
2002 – 2006 - Implementation and continuation of stocking as recommended by biological staff.

Objective: Evaluate the result and impact of stocking robust redhorse in the Broad River.
Schedule: 2001 – Assignments of duties and responsibilities.
2002 – Identification and prioritization of research needs. Identification of funding and selection of research facilities and personnel. Implementation of identified research.
2003 – 2006 – Continued identification of research needs and funding sources. Publication of resultant findings and implementation of appropriate findings.

Discussion Points

The intent of the effort is restoration rather than experimental. The source of broodstock is not yet clear but the initial thought has been to put in a broad spectrum of fish and let the river sort it out.

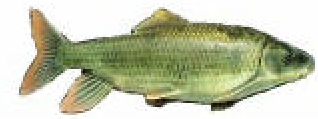
The exclusive use of developed captive broodstock is genetically too limiting because it selects for captive survivors. A better choice is stocking captive broodstock supplemented with wild fish.

There are concerns, however, about the long-term availability of wild fish and about “gamete mining.” So, the plan is to develop and use a captive broodstock and to bring in wild fish when possible. The size of the population in the Savannah River is unknown and more information is needed to determine its fit as a source of fish for the Broad.

Surveys of the Broad River, SC have collected other suckers but no robust redhorse. Additional surveys, below Columbia may be undertaken. Surveys of the Tyger and Enoree rivers will be conducted next year. But at this point, there are no plans to stock other rivers. Mussel surveys were conducted in the past year and will continue in the Broad River but the only endangered mussel in SC is not known to be in the Broad River watershed.

Habitat enhancement and restoration is addressed in SC’s omnibus act and plan. The State and power companies are inventorying the habitat in the Broad River watershed. Most of the dams on the Broad River, SC have been re-licensed, so FERC re-licensing issues will not be involved in the short-term.

REINTRODUCTION MANAGEMENT



Stocking Scenario in Georgia's Rivers for Fall 2001 – Spring 2002 – Discussion

The stocking scenario discussion began with a series of tables summarizing relevant information for each river in Georgia including the stocking history, stocking pros and cons, and stocking proposal for 2001. The first table (Table 10) summarizes the number of fish that are expected at harvest of the various hatcheries, while the last table summarizes proposed 2001 stockings for all rivers. The presentation of the following tables was followed by substantial discussion.

Table 10. Harvest estimates for fall 2001 – all hatcheries.

Hatchery	Pond Number	Size (acres)	Number Stocked (Phase I)	Number Stocked (Phase II)	Estimated Harvest
Burton	4	0.4	--	518	400
Walton	12	1.0	7,900	--	1,600
	5	0.5	3,900	--	800
McDuffie	9A	0.4	--	1,880	900
Dennis Wildlife Center	55	1.0	--	5,274	2,500[1]
Totals	--	--	11,800	7,672	6,200[2] - 2,400 Phase I - 3,800 Phase II

[1] A total of 500 Phase II will remain at Dennis Wildlife Center for broodfish production.
[2] A total of 5,700 (2,400 Phase I and 3,300 Phase II) estimated to be available for stocking riverine and pond refugial sites. Actual harvest could range from 1,000 to 10,000.

Table 11. Broad River, Georgia stocking history, stocking proposal and stocking pros and cons.

Stocking History	**Stocking Proposal**
Total stocked: 32,189 545 1993 yc (3 year old juveniles) 1,424 1995 yc (Phase II) 27,482 1997 yc (24,256 Phase I, 3,226 Phase II) 2,738 1998 yc (Phase I)	Total: 1,000 700 Phase I (2001 yc) 300 Phase II (2000 yc)
All stockings from Oconee River stock between 1995 – 1998.	Numbers to be divided evenly between 2 Hudson River sites at Highway 29 and Highway 106.
Stocking halted after Savannah R. population discovered and genetic differences between Oconee and Savannah strains were found.	

Stocking Pros	**Stocking Cons**
Good survival of initial stockings.	Portions of river difficult to sample.
Monitoring proves that smaller fingerlings (Phase I) can be stocked successfully.	Increased probability of migration thru Clarks Hill, Stevens Creek, and Augusta dams; mixing of Oconee and Savannah gene pools.
Early evidence of spawning behavior.	
Stocking additional year classes would enhance genetic viability of stocked population.	
Stocked population could serve as another broodfish source.	

R E I N T R O D U C T I O N M A N A G E M E N T

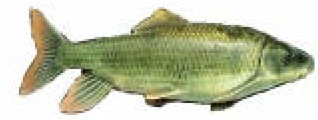


Table 12. Ocmulgee River Stocking history, stocking proposal and stocking pros and cons.

Stocking History	Stocking Proposal
Flood event in 1998 caused several refugial ponds at PNWR to overflow.	Total: 4,000 1,000 Phase I (2001 yc) 3,000 Phase II (2000 yc)
Several hundred to a maximum of 1,000 fingerlings from 95, 97, and 98 yc escaped (Oconee stock).	Divide evenly among 3 sites: Highway 16, Smith Mill and Wise Creek.
Fish entered Ocmulgee River 7.1 RM below Juliette Dam.	Stock only if CCAA in effect.
Two were recaptured in June and October 1999 about 55 and 75 RM below Juliette Dam.	Stock other rivers according to priorities if CCAA not in effect

Stocking Pros	Stocking Cons
Excellent water quality, habitat, and food supply between Lloyd Shoals and Juliette dams (project area).	Stocked fish could leave project area, possibly alter gene pool of small wild population 50 to 80 RM downstream.
Low abundance of flathead catfish.	CCAA difficult to develop and implement.
CCAA (if implemented) provides regulatory framework and funding mechanisms for monitoring and research.	Major urban area (Macon) 22 RM downstream of project area.
Partnering approach could serve as model for other reintroductions below hydroprojects	Portions of project area difficult to sample.

Table 13. Ogeechee River Stocking history, stocking proposal and stocking pros and cons.

Stocking History	Stocking Proposal
Total stocked: 20,991 1,762 1997 yc (Phase I) 876 1998 yc (Phase II) 10,328 1999 yc (Phase I) 8,025 2000 yc (Phase I)	Total: 350 350 Phase I (2001 yc)
All stocked in the Piedmont portion of the upper Ogeechee River at Mayfield and Jewells Mill	Divide evenly between 2 sites: Jewells Mill and below low head dam at Mayfield.

Stocking Pros	Stocking Cons
Undeveloped watershed.	Upper river isolated and difficult to sample.
Low sedimentation, good water quality.	Less suitable spawning habitat than other sites.
Annual DNR SS program assures monitoring effort.	Less evidence for previous existence of robust redhorse population.
Monitoring to date has documented survival and growth of stocked fish.	
No flathead catfish in basin, low predator densities in upper basin.	
Additional year classes will enhance genetic diversity of stocked population.	
Could serve as broodfish source, although difficult to sample.	

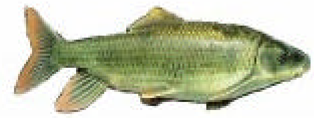


Table 14. Oconee River Stocking history, stocking proposal and stocking pros and cons.

Stocking History	Stocking Proposal
Total stocked: 177 46 1995 yc 66 1997 yc 6 1998 yc 59 1999 yc	Total: 78 30 Phase I (2001 yc) 42 Phase II (2000 yc) 6 Juveniles (1998 yc)
All fish stocked as Phase III or older juveniles in 2000 and 2001	Divide evenly among 4 sites: Hardwick ramp, Avant ramp, Balls Ferry and Beaverdam WMA
Equally divided among 3 sites between Milledgeville and Dublin.	Formal study proposal will be developed to evaluate survival, growth, and recruitment levels of stocked fish; affects of various stocking regimes on genetic characteristics of the wild population.
Current Stocking Criteria established by RRCC 1. Stocking limited to a maximum of 100 fish in any year. 2. Stocking should be associated with research objectives.	

Stocking Pros	Stocking Cons
Uncertain	Uncertain

Table 15. Details of stocking history for the Oconee River.

Date Stocked	Location	Year Class	Number Stocked	Average Length (mm)	Average Weight (g)
23 Feb. 2000	Hardwick, Balls	1995	36	362 (14 in)	615 (1.4 lbs)
	Ferry, Beaverdam	1997	54	283 (11 in.)	293 (0.6 lbs)
	WMA	1998	2	268 (10 in)	225 (0.5 lbs)
			92 subtotal		
9 Mar. 2001	Hardwick	1997	5	334 (13 in.)	466 (1.0 lbs)
		1999	17	212 (8 in)	119 (0.3 lbs)
			22 subtotal		
19 Mar. 2001	Balls Ferry	1995	10	361 (14 in.)	573 (1.3 lbs)
		1997	7	292 (11 in.)	282 (0.6 lbs)
		1999	1	268 (10 in.)	200 (0.4 lbs)
			18 subtotal		
9 Jul. 2001	Avants, Beaverdam	1998	4	274 (11 in.)	239 (0.5 lbs)
	WMA	1999	41	241 (9 in.)	172 (0.4 lbs)
			45 subtotal		
Totals		1995	46	361 (14 in.)	606 (1.3 lbs)
		1997	66	288 (11 in.)	305 (0.7 lbs)
		1998	6	272 (11 in.)	235 (0.5 lbs)
		1999	59	234 (9 in.)	158 (0.3 lbs)
			177 Total		

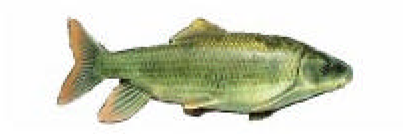


Table 16. Recapture history in the Oconee River.

Year	Number Stocked (Cumulative)[1]	Number Stocked Captured (no/hr)	Percent Stocked Recaptured	Total Number Captured (no/hr)[2]	Percent Sample from Stocked Fish	Number New Recruits[3]	Number New Recruits from Stocked Fish	Percent New Recruitment from Stocked Fish
2000	92 (1995, 1997, 1998 yc)	1 (0.06)	1.1	70 (5.1)	1.4	4	1	25
2001	132 (1995, 1997, 1998, 1999 yc)	3 (0.14)	2.3	46 (2.8)	6.5	4	3	75
Total	132	4	3.0	116	3.4	8	4	50

[1] Prior to sampling in April – May of each year.
[2] All sampling conducted during broodfish collection efforts in April-May.
[3] Less than 520 mm.

Table 17. Recaptures of stocked robust redhorse in the Oconee River.

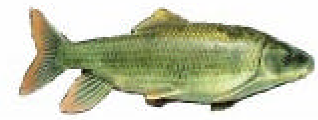
Year Class	Date Stocked	Date Collected	Length at Stocking (mm)	Length at Recapture (mm)	Growth (mm)	Stocking Weight (g)	Recapture Weight (g)	Growth (g)	Distance Traveled (km)
1995	23 Feb 2000	2 May 2000	425 (16.7 in)	436 (17.2 in)	11 (0.4 in)	1,120 (2.5lbs)	1,320 (2.9 lbs)	200 (0.4 lbs)	2.1 (up)
1995	23 Feb 2000	1 May 2001	410 (16.1 in)	510 (20.1 in)	100 (3.9 in)	900 (2.0 lbs)	2,500 (5.5 lbs)	1,600 (3.5 lbs)	7.5 (up)
1997	23 Feb 2000	1 May 2001	272 (10.7 in)	421 (16.6 in)	149 (5.9 in)	234 (0.5 lbs)	1,160 (2.5 lbs)	926 (2.0 lbs)	61.3 (down)
1995	NA	7 May 2001	NA	360 (14.2 in)	NA	NA	860 (1.9 lbs)	NA	NA

Table 18. Summary of proposed stocking plan for 2001 – all rivers.

Prioritized Stocking Sites	Phase I (2001 yc)	Phase II (2000 yc)	Juveniles (1998 yc)	Stocking Date
Ocmulgee River[1]	1,000	3,000	--	Oct. - Nov. 2001
Oconee River			--	
Broad River, GA	700	300	--	Oct. - Nov. 2001
Ogeechee River	350	--	--	Oct. - Nov. 2001
Piedmont NWR	250	--	--	Oct. - Nov. 2001
Central GA Branch Station	100		--	Oct. - Nov. 2001
Totals[2]	2,400	3,300		

[1] If CCAA not in effect by Nov., fish will be stocked at other sites. Stocking in the Ocmugee River will then be delayed until 2002. No Phase II will be available in 2002 – an additional 100-400 fingerlings from 1998, 1999 and 2000 yc available from PNWR.
[2] Actual total may vary from 1,000 to 10,000.

R E I N T R O D U C T I O N M A N A G E M E N T



Discussion Points

The survival rate of the Broad River, GA stocked fish is unknown. Fifty fish have been collected from the Broad River and from Clarks Hill Reservoir. That shows good survival. It is remarkable that at least 1 fish is found at every visit to the rocky shoals.

The CCAA for the Ocmulgee River provides hold harmless assurances to the power company but a federal agency may not be held harmless. As the RRCC re-introduces the fish into more of its historic habitat, more questions about holding harmless will come up. At the same time, if the efforts succeed, the fish will be less threatened and the question will lose some of its import. The RRCC should develop a policy to specifically designate stocked populations as experimental, restored, essential, etc.

Stocking in the Broad River ceased two years ago, when wild Savannah River robust redhorse were discover. However, two risks remain for the Oconee fish introduced in the Broad River. On the one hand there is an increased risk of contaminating the population of fish in the Savannah River with another genetic strain if stocking the Broad River continues. On the other hand, if more year classes and different families are not added into the Broad River through additional stocking, there are risks of those fish being a genetically restricted population.

The concerns about stocking are not so much about genetics as it is about survival. A big effort is needed to estimate the survival rates and the Broad River may be the best opportunity to study this question. There is good diversity within the year classes stocked in the Broad River. However, which families have survived in the river remains unknown.

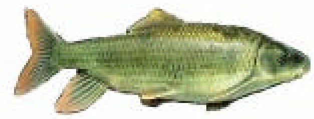
There are 99 fish at Fort Gordon from the Savannah River as a refugial population.

The CCAA calls for at least 4000 stocked into the Ocmulgee River. Multiple year classes will be used and tagged (wire and PIT). The PIT tags will be placed on different locations of the fish bodies to tell them apart and some telemetry tagging is expected also. The Ocmulgee has good habitat, so a large population is expected.

Four fish were recaptured on the Ogeechee River. They had grown quite well in the time that they were in the river.

The policy in place now for stocking in the Oconee states that no more than 100 fish will be released into the river in any one year. Furthermore, the fish that are placed into the Oconee should be part of a research study. It may be that the findings from studies undertaken on the Oconee can be safely extrapolated to the Broad and Ogeechee rivers. It would also be feasible to remove research efforts from the Oconee and conduct the research in the Broad and Ogeechee rivers.

On the Oconee, shocking tends to yield fish in the 410 mm to 450 mm size classes. On the Broad River shocking tends to bring up smaller fish. In the Savannah River, both large and small fish



were seen. But the robust redhorse remains on the shoals only for a short period of time. They are obviously spending time elsewhere. It might even be that the population in the Oconee is not falling but that there are undetected fish.

In terms of sufficient reason to stock more fish in the Oconee River, there is concern that the population is crashing or is about to crash. Others believe that the population is still in good shape. It might be that the upper and lower bounds of the population estimate should be the focus rather than the point estimate of the population in the Oconee. So far there has not been a statistical trend up or down.

Quite a bit of sampling was done on the Altamaha but it was at a time of low water. The entire Ocmulgee has been sampled and the Oconee is sampled every year. The distance the larvae drift is largely speculation.

It is clear that leaving the fish in hatchery ponds is not preferred due to the lower year-to-year survival rates.

Generally, the thought is that if the population of fish in a river is sustainable, there should be no stocking of fish in the river. If the population does not appear to be sustainable, then stocking should be done. If it is unclear whether the population is sustainable, then stocking smaller numbers may be preferable.

Stocking the Oconee would be beneficial if the wild population is on a steep decline, as some believe. Three or 4 new recruits from previously stocked fish have been seen on the spawning beds. But the goal should not be augmentation.

Stocking Decision for 2001 - 2002

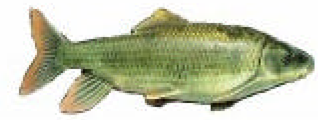
Table 19 presents the final stocking scenario agreed to by the RRCC with the stipulations and specifications following the table.

Table 19. Stocking decision for 2001 – 2002.

Location	Oct./Nov.	Feb. w/ CCAA	Feb. w/o CCAA
Ocmulgee		3500	
Broad			
Ogeechee	1350		3500
Piedmont NWR	250		
Central Georgia Research Station	100		
Oconee		0 to 80	0 to 80

- If the CCAA can be signed and implemented in time, the fish should be stocked in the Ocmulgee in February.

R E I N T R O D U C T I O N M A N A G E M E N T



- The RRCC split evenly on whether to stock additional fish in the Broad River, GA. Half believe it is more important to safeguard the integrity of the population of the Savannah River fish and half believe that the genetic diversity of the fish in the Broad River should be increased. The decision was to place no additional fish in the Broad River in 2001/2002. The risks associated with the Broad River (stocking more fish or leaving the genetically limited population there) should be assessed. In addition, research in the Broad River should be conducted to determine if the stocked fish are reproducing.

- The Georgia TAG was charged with looking very carefully at stocking in the Oconee River. The small number of fish should be tied to a research effort that the TAG should specify. This might mean placing about 30 fish in the river with telemetry devices to track movements. There was agreement that the number of fish should remain quite small.

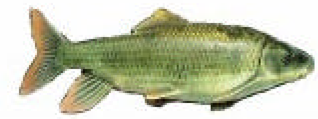
- A pure Savannah River refugial population will need to be placed in some pond or stream in the Savannah River watershed.

- Fort Stewart has a contract to monitor the Ogeechee for robust redhorse.

- The RRCC will seek to negotiate the best possible operations of dams and other facilities so as to minimize impact to pre-existing legal users of the rivers in which fish are re-introduced and to promote benefits for the robust redhorse.

- The RRCC must develop a supplemental breeding policy that specifies production goals, stocking proposals, and disposition of any excess fish.

ANNOUNCEMENTS



Status of Grant for Robust Redhorse Genetics Workshop – Greg Looney, USFWS

A grant application has been submitted for funding for a robust redhorse genetics workshop.

Plans for Fish Passage Structures on the Savannah River – John Biagi, GA DNR

A team comprised of individuals from SCDNR, GDNR, USFWS, and NOAA met to discuss fish passage issues for the Savannah River segment below Strom Thurman dam. There are 3 dams on the Savannah River below Strom Thurman dam, Stevens Creek, Augusta Diversion dam, and New Savannah Bluff Lock and Dam. The USACOE is in the process of refurbishing the New Savannah Bluff Lock and Dam, part of which includes installation of a fish passage system. Additionally, the City of Augusta is currently under a FERC relicensing process. These 2 situations could provide the opportunity to open approximately 18 additional miles of the Savannah River to migratory fish populations.

The team discussed the issues associated with moving fish both upstream and downstream of the dams. Concerns for the passage of fish upstream were primarily related to water quality. Strom Thurman dam passes water that is cooler than normal and has low dissolved oxygen in late summer. For this reason, the team is developing a recommended strategy that will not pass fish to Thurman dam unless the USACOE improves water quality. Species of fish targeted included shad, eels, striped bass, robust redhorse, and sturgeon.

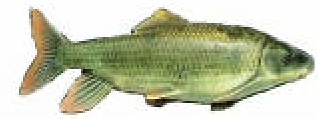
Bob Jenkins announced that a fish ladder has just been completed in Quebec, Canada so that the copper redhorse might travel up the Richelieu River.

Status of Robust RedhorseVideo Distribution – Jimmy Evans, GA DNR

The Film and Video Unit of the GA DNR began work on a documentary of the robust redhorse recovery effort in 1996. The Wildlife Resources Division of the GA DNR, The Environmental Resource Network (TERN), and GPC funded the project with the objective of documenting the various aspects of the recovery effort, including:

- initial Oconee River discovery,
- story of the connection with eighteenth century naturalist Edward Cope,
- causes for historic decline and present threats,
- natural history, and
- process of recovery through stakeholder partnerships.

Filming began and a first draft of the script was prepared in 1997. The script was revised several times and additional segments filmed as new discoveries on the status and natural history of the species were made. Segments were filmed detailing collection efforts and habitat features on the Oconee, Ocmulgee, and Savannah rivers as well as artificial propagation efforts, fingerling



harvests, stocking in ponds and rivers, and present and historical threats. Bud Freeman of the University of Georgia Institute of Ecology provided video of spawning behavior at one location on the Oconee River filmed in 1995. Numerous interviews were filmed with scientists and key stakeholders.

A final script was prepared and revised in late 1999 – early 2000 and a screening of the first draft of the video was held in August 2000. Minor changes were made and the film was shown at the annual meeting of the RRCC in October 2000. The film was completed and available for distribution in late 2000. One hundred copies were purchased and distributed in January 2001.

Recent Developments

- The video was listed in the GA DNR Film Catalog in September 2001. A total of 8000 catalogs have been mailed and 140 videos have been distributed to date. The Film and Video Unit has received four requests for loan copies. The GA DNR has been asked to provide addresses of anyone wanting a copy of the film catalog.

- The video has been shown at 4 film festivals.
    - U.S. International Film and Video Festival
    - International Wildlife Film Festival
    - The Cindy Competitions
    - Outdoor Writers of America

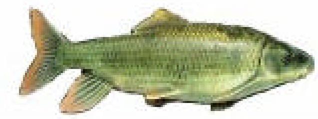
- A draft Video Distribution and Media Plan was developed by USFWS, GA DNR, and GPC media specialists. Job responsibilities of all involved were shifted to other projects and there has been relatively little follow up.

- The original video failed to list the USFWS as one of the MOU signatories. The USFWS funded the revision and will purchase 60 copies of the new version for distribution to USFWS offices nationwide and congressional delegations in Georgia, South Carolina, and North Carolina.

- A short segment on the robust redhorse will appear on Georgia Outdoors in March 2002

Oconee River Bank Stabilization Project Update – Terry DeMeo

In September 2000, the NRCS completed a bank stabilization project to anchor 1100 feet of bank on the Oconee River about 10 miles south of Milledgeville and about 5 miles upstream of a major spawning area for the robust redhorse. The private landowner had lost over 2 acres of farm to erosion over the past 50 years. With technical assistance from the NRCS, over 700 mature trees were harvested from the farm and cabled along the riverbank to slow the current and allow sediment and permanent vegetation to stablize the bank. Funding for the project was a joint effort between the Environmental Quality Incentive Program through NRCS and Partners for Wildlife,



administered by the Georgia Soil and Water Commission. This riverbank stabilization method has been tried successfully in North Carolina and on smaller rivers in north Georgia but never on a river of this magnitude.

Since the installation of the revetment project, two major storm events tested the project when the river covered the trees and floodplain to a depth of about 2 feet in some areas. All trees have remained in place. It appears that the bundled trees on the first 100 feet of the project floated with the rise in the river but returned to their original position. Some erosion occurred in the first trench that was excavated and filled to hold the steel cables and deadman logs. Sediment is collecting in the revetment and some permanent vegetation (mainly grasses and hardwood species) has become established.

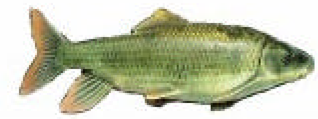
To help combat the increasing problem of streambank erosion in the Broad River watershed, the Chestatee-Chattahoochee Resource Conservation District, through a grant from the GA DNR, Environmental Protection Division, is implementing a project designed to demonstrate to landowners the positive effects of tree revetments on eroding streambanks. This project calls for 15 tree revetment sites, plus additional BMPs to be installed on selected streams throughout the Broad River watershed.

Presentation on the RRCC at the AZA National Meeting – Terry DeMeo

A presentation on the robust redhorse and the RRCC was made at the American Zoological and Aquaira (AZA) Association's national conference, which carried the theme: Where the Rivers Run Wild. The presentation titled, *The Dammed and the Wild: Conservation Partnerships for Rivers and Fish*, was made in the Aquatic Conservation concurrent session along with the following:

1. Seahorse Research and Conservation Efforts in Public Zoos and Aquariums, Jeff Boehm, John G. Shedd Aquarium (coordinating loose international conservation efforts).
2. Summary Report on Malagasy Freshwater Fish Conservation Program, Rick Haeffner, Denver Zoo (endangered Madagascar fish; land use changes; display and captive reproduction partners).
3. Aquatic Conservation and Captive Breeding – Where is the Commitment?, Doug Sweet, Detroit Zoological Park (skiffia collection, 1979, captive breeding, habitat protection and rehabilitation; commitment).
4. A New Partnership for Freshwater Mussel Conservation, Doug Warmolts, Columbus Zoo and Aquarium (mussel conservation and research facility for propagation and refuiga and public education; USFWS, Ohio DNR, Ohio State University, Ohio River Valley Ecosystem Research Team, The Nature Conservancy, and Mussel Mitigation Trust).

The RRCC presentation highlighted the rediscovery of the fish and how the Endangered Species Act provides for creative conservation parternships, which led to the development of the MOU that formed the RRCC. It included an overview of the RRCC members and activities and lessons



that could be relevant to aquarias and zoos. The presentation underscored that the RRCC's voluntary multi-stakeholder approach has been extraordinarily successful in achieving its goals. It attributed those successes to the full and shared partnership, in which individual agency and corporate cultures contribute to and profit from the process but do not own the larger effort. The presentation closed by suggesting that given the current political climate and fiscal constraints, creative partnerships may be the best approach for achieving conservation and research goals in the 21st century.

New regulations in North Carolina – Danielle Pender, NC WRC

North Carolina has proposed a new regulation to ban gill nets on the Pee Dee River.

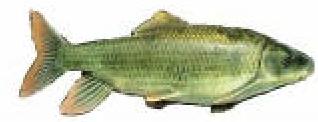
Robust Redhorse Display – Jimmy Evans, GA DNR

Bass Pro shops are planning a huge new store in Atlanta. They plan to build a river aquarium and have asked to place robust redhorse in the display. They are willing to put up educational plaques, etc. The plan is to provide them with 14 to 16 inch fish from the Broad River. This will be a good opportunity to learn about the fish's interaction with other species in a riverine display and might benefit the SCA.

Robust Redhorse Artwork – Chris Skelton, GA DNR

Joe Tomelleri's original artwork of the robust redhorse has been purchased and will be presented to Jimmy Evans in recognition of his commitment. Dr. Skelton will also coordinate the purchase of limited edition reprints for those interested.

B U S I N E S S



Establishment of a Carolina's Technical Advisory Group

Increased activities with robust redhorse in the Broad River, South Carolina and the Pee Dee River, North Carolina led the RRCC to establish a Carolina Technical Advisory Group (TAG). Over time, it may be that the Carolina TAG will need to separate into 2 TAGs, 1 for each state.

The Carolina TAG will be a project team/work group for carrying out the RRCC agenda in the Pee Dee River system through the year and will develop restoration goals. It will bring recommendations to the full RRCC at the annual meeting for approval.

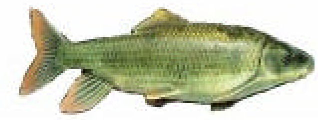
The Chair of the RRCC serves as the chair of all TAGs. The Chair and Vice Chair of the RRCC will serve as members of the Carolina TAG but may take turns attending meetings. The Project Managers for SC and NC will serve on the TAG. Membership may allow for other agency representatives to be added to the process.

Priority Work Items for 2002

Each year the RRCC develops a list of work items that are a priority to accomplish in the forthcoming year and charges the GA TAG with the authority to coordinate or complete the work items to the best of its ability. The RRCC established the following work items for the coming year (not in priority order).

- Develop RRCC policies and goals for each river basin/management action including status surveys.
- Seek funds for a telemetry study in the Savannah River.
- Develop and bring online the Web page for the RRCC.
- Pursue the USFWS coordinator position of robust redhorse.
- Review and revise the Conservation Strategy.
- Finalize the CCAA for the Ocmulgee River.
- Conduct the annual status surveys as prioritized.
- Identify and prioritize habitat needs and restoration sites.
- Determine by January 2002 the number of fish needed for each river basin/management action to inform broodstock and hatchery production decisions.
- Continue to seek funding for, coordinate, and conduct a robust redhorse genetics workshop to discuss genetics information on robust redhorse to date, discuss implications, and develop recommendations.
- Develop a genetics management plan to inform genetics goals.
- Assist in establishing the Carolinas TAG.

B U S I N E S S



Research Priorities in 2002

The following lists the research priorities for 2002 established at the 2001 RRCC Annual Meeting.

- Pursue the development of a morphometric key for RRH, silver, spotted, and brassy jumprock.
- Conduct the telemetry study with fish stocked in the Oconee.
- Update the database of robust redhorse captures.
- The South Carolina Aquarium will look at diet and medication treatments.
- Look at the past year classes stored in formalin. (This is a very low priority.)
- Study water quality at sites along the Oconee, Ocmulgee, and Altamaha Rivers to determine if there might be fresh water sources of strontium

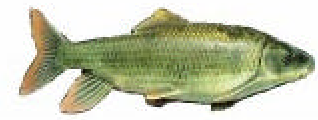
Genetics research identified by Ike Wirgin in priority order:

- Characterize the mtDNA haplotypes and microsatellite genotypes in robust redhorse from other newly discovered populations.
- Compare microsatellite diversity in Oconee River broodstock (spring 2001) to that in various life stages of hatchery-reared offspring.
- Complete comparison of microsatellite allelic frequency in silver redhorse from Oconee, Savannah and Pee Dee Rivers.
- Species identification of robust redhorse larvae from the Oconee (2001 and 2002).
- Characterize and compare the mtDNA haplotypes and nuclear DNA in Carolina redhorse to other species.

Other genetics research not in priority:

- Determine the effective population through genetic estimates of Nec (captive) and New (wild).
- Study the fish in the Broad and Ogeechee rivers to test the assumption of 50% mortality by determining the proportion of Phase I fish that live adulthood.
- Assess the validity of the theoretical underpinnings of the assumption that the population is really comprised of random mating.
- Assess if the population of fish in the Oconee River is stable
- Test the effects of overlapping rather than discrete generations in the modeling.

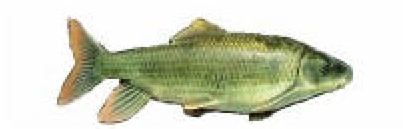
A T T A C H M E N T S



Attachment 1. Participants of the 2001 RRCC Annual Meeting

Andrews, Chris, Executive Director, South Carolina Aquarium
Andrus, Fred, Department of Geology, University of Georgia
Bailey, William, Planning, Savannah District, U.S. Army Corps of Engineers
Biagi, John, Assistant Chief of Fisheries, Georgia DNR - WRD
Bowles, Tom, South Carolina Electric & Gas
Caldwell, Liz, Oconee National Forest Office, U.S. Forest Service
Carlton, Stewart, Fish & Wildlife Research Unit, USGS GA Coop
Coughlan, Dave, Environmental Center, Duke Power Company - MG03A3
Crutchfield, John, Harris Energy and Environment Center, Carolina Power and Light
Cull, Rebecca, Fish & Wildlife Research Unit, USGS GA Coop
DeMeo, Terry, Carl Vinson Institute of Government, UGA
Dowswell, Laurel, Piedmont National Wildlife Refuge, U.S. Fish and Wildlife Service
Evans, James, Fisheries Section, GA DNR - WRD
Feldt, Jim, Consultant, Consensus Builders
Fiumera, Anthony, Biology Department, Pennsylvania State University
Freeman, Byron, Institute of Ecology, UGA
Grant, John, Santee Cooper Power Company
Harris, Bebe, Education Specialist, South Carolina DNR
Hill, Amanda, Ecological Services, U.S. Fish and Wildlife Service
Isely, Jeff, South Carolina Coop Unit, Clemson University
Jenkins, Bob, Biology Department, Roanoke College
Jennings, Cecil, Fish & Wildlife Research Unit, USGS GA Coop
Johnson, Judith, Nongame & Endangered Wildlife Program, NCWRC
King, Ross, Assistant Director, Association County Commissioners of Georgia
Looney, Greg, Warm Springs Fish Technology Center, U.S. Fish and Wildlife Service
McMillan, Whit, Conservation Education Manager, South Carolina Aquarium
Modde, Tim, Colorado River Fish Project, U.S. Fish and Wildlife Service
Nichols, Mike, Environmental Lab, Georgia Power Company
Pender, Danielle, Piedmont Regional Coordinator Habitat Cons. Program, NCWRC
Porter, Brady, Department of Genetics, University of Georgia
Self, Ross, Freshwater Fisheries Section, South Carolina DNR
Shelton, Jay, Warnell School of Forest Resources, UGA
Sheppard, David, Fish & Wildlife Research Unit, GS GA Coop
Simpson, Tom, FERC Re-licensing Specialist, CH2MHill
Sinclair, Tom, Fisheries Section, U.S. Fish and Wildlife Service
Skelton, Chris, GA DNR - NONGAME
Starnes, Wayne, Research Curator of Fishes, NC State Museum of Natural Sciences
Summer, Stephen, M/C PO 5, South Carolina Electric and Gas
Troxel, Jay, Region 4 RRH Coordinator – Fisheries, U.S. Fish and Wildlife Service
Tucker, Sandy, Georgia Field Supervisor, U.S. Fish and Wildlife Service
Walmsley, Greg, Piedmont National Wildlife Refuge, U.S. Fish and Wildlife Service
Wilkins, David, Freshwater Aquarist, South Carolina Aquarium
Williamson, Holt, Dexter National Fish Hatchery Technology Center, U.S. Fish and Wildlife Service
Wirgin, Ike, Nelson Institute of Environmental Medicine, NYU School of Environmental Medicine

A T T A C H M E N T S



Attachment 2. Nine Basic Lessons Learned by a Captive Broodstock Manager

We have learned, while unintentionally, many useful lessons while engaged in our captive propagation program for razorback sucker at Dexter. These lessons may be of value to other broodstock managers in other programs.

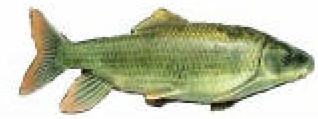
1. The emerging role of the broodstock manager responsible for developing and using captive broodstocks of imperiled fishes demands that she be a complete manager, not just a skilled technician or fish culturist “managing the fish”.

2. The broodstock manager must thoroughly understand and appreciate her unique position in solving complex natural resources management problems in a complex management environment. That understanding includes awareness of the various domains and value sets that create the total management environment (political, economic, sociocultural, legal, institutional as well as ecological) and respect for different points of view.

3. The broodstock manager must manage concepts, particularly genetics-based concepts. She must possess the knowledge to understand and apply evolutionary theory, genetics conservation principles, and risk management concepts to effectively analyze problems and make superior decisions in choosing animal breeding practices and developing fish culture methods necessary to and achieve genetics conservation goals and objectives.

4. The broodstock manager must manage the genetics experts. To successfully manage the experts, the broodstock manager must have a strong sense of her professional identity. She must understand her role with respect to theirs and assist the experts in recognizing she is an expert in her own right and they will respect her domain of professional responsibility. In addition, she must possess the knowledge to understand evolutionary theory and genetics conservation principles to comfortably engage and effectively interact with genetics experts. She must be able to interpret and analyze fisheries management problems from a genetics conservation perspective and formulate critical management questions for the genetics experts to address. She must be able to evaluate the expert’s answers to her questions as potentially useful information in order to make the best possible decisions in her program and to defend them.

5. In addition to rigorous management of fish (i.e. fish health and care), the broodstock manager must manage the data or information generated from the fish or the activities directed at the fish. Effective data management includes storage and accesses to all data relevant to program success. For example, the broodstock manager must maintain a verifiable record of broodstock provenance much like a “chain of custody” record for evidence used in legal proceedings. A record of that nature includes geographic and genetic origin of founders; an individual’s identifying characters i.e. PIT-tag numbers and genetic/phenotypic profiles, its breeding history (method, mate, family lot), and progeny disposition and/or performance under defined management circumstances and environmental conditions. Timely and reliable genetics information is so vital for successful endangered fish broodstock management and



production in a gene pool maintenance program that Dexter has developed its own in-house genetics capability centered around a fully equipped genetics laboratory staffed with experts and technicians skilled in advanced analytical and statistical methods.

6. The broodstock manager develops and manages the captive propagation process to accomplish captive propagation goals. The broodstock manager manages all captive propagation program steps as an iterative and adaptive process beginning with her orientation and location within the total management environment; she analyzes the management problem and reduces pertinent elements to her program goals and objectives the achievement of which contributes to overall program success; she plans and guides execution of specific activities to achieve results; she evaluates the results in terms of desired outcomes, goals and objectives; finally, she responds adaptively to improve the captive propagation process, her performance and the products delivered.

7. As a partner in a comprehensive management process, the broodstock manager must be an active team member. The emerging role of the broodstock manager responsible for developing and using captive broodstocks of imperiled fishes requires close communication and cooperation with a number of individuals and parties involved in high profile and complex management efforts.

8. The broodstock manager understands that developing and managing a scientifically sound and sustainable captive propagation and broodstock management program requires considerable trust and long-term commitment from program participants and adequate funding from interested parties and responsible agencies. To enlist the long-term support of that nature and magnitude the broodstock manager depends in large measure on her personal reputation and professional credibility.

9. The broodstock manager understands that these basic management lessons are applicable to other problems, programs and species in different management environments.