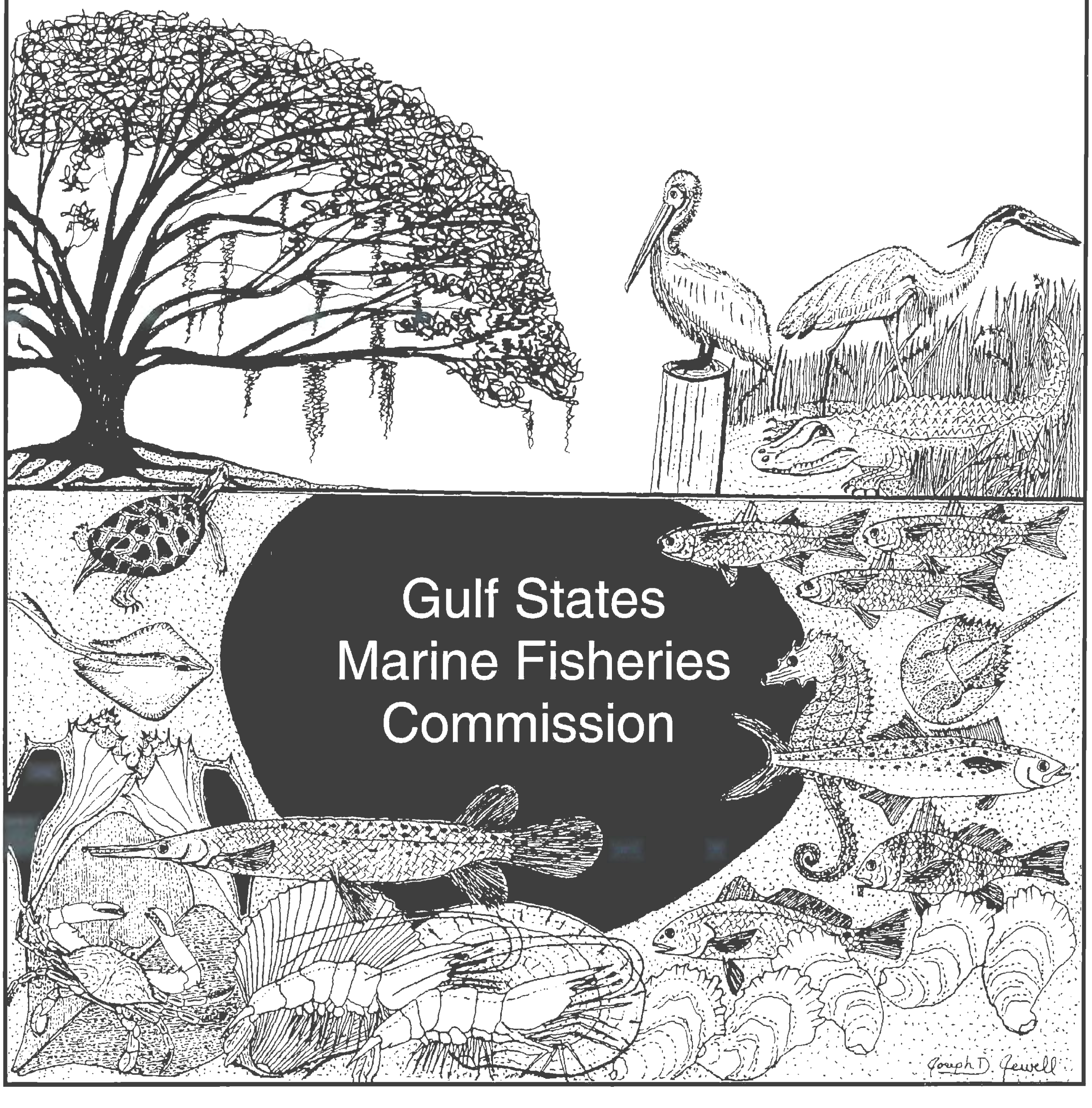
# GULF OF MEXICO STRIPED BASS RESTORATION WORKSHOP

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# *Gulf of Mexico Striped Bass*

# *Restoration Workshop*

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SPORT FISH RESTORATION

Gulf States Marine Fisheries Commission

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## Welcome and Workshop Purpose

*Columbus Brown, U.S. Fish and Wildlife Service*

Good Afternoon and welcome to Pensacola Beach and the Gulf Striped Bass Restoration Workshop. We are certainly glad you were able to join us for what I trust will be an extremely interesting and productive session. I am Columbus Brown, Assistant Regional Director for Fisheries in the Southeast Region of the US Fish and Wildlife Service, and I will be the moderator for the workshop.

This workshop is being jointly hosted by the Gulf States Marine Fisheries Commission (GSMFC) and the U.S. Fish and Wildlife Service (FWS). I would also like to acknowledge the Federal Aid Program of the FWS in providing the funding to make this workshop possible.

The GSMFC is handling all the logistical details in holding the workshop, which includes producing a meeting summary that will be made available to all participants and anyone else interested in receiving a copy. In order to do this they will be making a recording of the meeting. Therefore, we ask that you state your name and speak loudly and distinctly when you have a question to ask or comment to make. At this time I would like to acknowledge Ms. Nancy Marcellus, the GSMFC Staff person who will be producing the recording and meeting summary.

I would also like to invite you to sign one of the meeting attendance rosters located on the table near the entrance to this room if you haven't already done so. Copies of the workshop agenda are also located back there, and you are welcome to pick up one of those.

### Fish and Wildlife Service Involvement in Gulf Striped Bass Restoration

Before going into specific workshop objectives, I'd like to talk a little about the FWS involvement with striped bass. We get our basic authority for assisting the states with co-managing anadromous species from the Anadromous Fish Conservation Act. Under this legislation we have been active partners with the states and National Marine Fisheries Service in restoring and managing numerous anadromous species across the country. The highly successful Atlantic coast striped bass restoration program was accomplished under this and supporting legislation.

Also, last year the FWS formally defined six priorities for its Fisheries Program activities. Two of these priorities directly relate to our involvement with striped bass in the Gulf. In accordance with these our interests are two-fold: 1) restoring interjurisdictional populations of striped bass in order to provide fisheries benefits; and 2) if appropriate, restoring these populations in order to preclude the need to list them under the Endangered Species Act.

Parallel with these priorities, the FWS Southeast Region published its *Fisheries and Aquatic Resources Strategic Plan* in June 1997. This plan identified as a major goal the restoration of Gulf striped bass populations in selected river drainages.

### Workshop Purposes and Goal

The purpose of this workshop is primarily to serve as an informational forum. We've invited presenters from a wide spectrum of both expertise and geography. Some will be presenting information not directly related to striped bass in Gulf drainages, but which we thought was pertinent to the Gulf striped bass restoration efforts. While the focus of this workshop is on coastal anadromous striped bass, we recognize the importance of reservoir striped bass stocking to downstream populations. We hope this workshop will expand the level of awareness regarding the status of Gulf anadromous striped bass populations, and help to identify biologists and other resource managers whose expertise may be helpful to us in future restoration efforts.

The workshop will also provide an opportunity to examine a number of specific on-going Gulf striped bass projects at about the mid-way point in their progress. The FWS, through its Fisheries Stewardship Initiative, funded a number of projects that are being carried out by state agencies and universities in Gulf rivers. While these projects officially began in 1997, most of the work so far has taken place this year, and progress to this point will be presented. More detailed information on the Fisheries Stewardship Initiative and the individual projects will be presented tomorrow.

A third and the most important workshop purpose is to help in beginning the process of revising the Gulf striped bass fishery management plan (FMP). The plan is an interjurisdictional FMP of the GSMFC. While you will be hearing more about the GSMFC and the FMP in a little while, I will say at this point that the plan, developed in 1986, is in need of revision. The GSMFC has decided to embark next year on the revision process, which will not be completed before the year 2000.

While we do not plan to make any decisions or come to any conclusions at this workshop with regard to the FMP revision, we hope that it will start folks thinking about where we ought to go in the future with restoration efforts. We hope this workshop will begin to frame some of the questions we should be asking as we undertake the revision process, and most importantly what the goals should be for our future efforts at Gulf anadromous striped bass restoration. Our vision is for a follow-up workshop, following completion of the Stewardship Projects, within a couple of years, to focus specifically on these questions.

**Introductory Presentations**

To set the stage for the workshop and provide some orientation and background, we will now have two overview presentations.

The first will be presented by Doug Frugé, the FWS Gulf Coast Fisheries Coordinator, located in Ocean Springs, Mississippi. He will be providing us the historical setting with regard to the present status of anadromous striped bass in the Gulf, as well as a summarization of what we think we know at this point.

The second overview presentation will be given by Ron Lukens, the Assistant Director of the GSMFC. He will be giving us a summary of the functions and responsibilities of the GSMFC, particularly as they relate to Gulf striped bass restoration and management, which includes, of course, developing and implementing the interjurisdictional FMP for striped bass in the Gulf of Mexico.

## Overview of Striped Bass in the Gulf of Mexico

*Doug Frugé, U.S. Fish and Wildlife Service*

Good Afternoon. I am going to be presenting a very brief summary of what we know about striped bass in Gulf of Mexico rivers, and some of the major advances in Gulf anadromous striped bass biology and management to the present time. Although the focus of this workshop is on anadromous striped bass, management of the "coastal" populations must take into account the establishment of fisheries for striped bass and striped bass hybrids in many reservoirs on Gulf rivers through stock enhancement. While dams have doubtless contributed to the demise of natural striped bass populations in the rivers, the reservoir stocks also contribute to the downstream populations. This fact also complicates the picture when questions of genetic integrity are considered, which I'll get into a little later. In some cases, management of the coastal populations is closely coordinated with the reservoir programs. In other cases, particularly in the case of the Mississippi River, it is not.

### Historical Distribution

While striped bass are most usually associated with Atlantic coast rivers, ranging from the St. Lawrence down to the St. John's in Florida, the species is known to have naturally occurred in northern Gulf of Mexico rivers. Most accounts indicate an original range from the Big Bend area of Florida to southeastern Louisiana (Hoese and Moore, Lee et al., Shipp, and Walls).

Hoese, H. Dickson, and Richard H. Moore. 1977. Fishes of the Gulf of Mexico: Texas, Louisiana, and Adjacent Waters. Texas A&M University Press. ISBN 0-89096-027-5.

Lee, David S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr. 1980. North Carolina State Museum of Natural History. ISBN 0-917134-03-6.

Shipp, Robert L. 1986. Dr. Bob Shipp's Guide to Fishes of the Gulf of Mexico. Marine Environmental Sciences Consortium of Alabama. ISBN 0-938917-03-X.

Walls, Jerry G. 1975. Fishes of the Northern Gulf of Mexico. T.F.H. Publications, Inc., Ltd. ISBN 0-87666-445-1.

### Major Rivers Within Potential Historic Range of Striped Bass in the Gulf of Mexico

While historical distribution based on classical ichthyological studies indicate the Lake Pontchartrain drainages as the western limit of distribution, there are commercial landings records for striped bass from as far south as Corpus Christi Bay in Texas in the late 1890s. This has led to some speculation that there could have been striped bass populations in some rivers farther west, including the Mississippi River.

Although reported as common by some early accounts, striped bass were probably never abundant in Gulf rivers compared to Atlantic populations. Commercial landings records exist for all Gulf states except Mississippi with total documented landings from 1887 to 1963 only a little over 118,000 pounds. Although directed recreational fisheries were also known to exist, we have no objective measures of historic striped bass population levels, except for the limited commercial catch information.

## Population Declines

First indications of concern with declining striped bass populations in Gulf rivers surfaced in the 1950s. By the late 1960s, striped bass had virtually disappeared from all Gulf rivers except for a remnant population in the Apalachicola-Chattahoochee-Flint river system in Florida.

## Possible Causes of Population Declines

Although we don't know the exact cause of striped bass population declines, it was probably a combination of factors, with some being more important in specific rivers than others. These are basically the same factors that were implicated in the Atlantic coastal striped bass declines of the 1970s.

Of probable foremost concern, dams and channelization may have had a number of effects in preventing access to or causing the destruction of habitats critical to striped bass. Sedimentation may also have played a factor in some drainages. The role of groundwater extraction in reducing flow volumes to springs that may have provided thermal refugia should not be overlooked. Changes in water quality resulting from agriculture, forestry or other land uses may have been factors, as well as changes in timing, quantity or velocity of water flow, which may have had impacts on spawning success and subsequent larval development.

Chemical contaminants are known to affect a variety of physiological processes, including reproduction, growth, susceptibility to disease, etc. One factor that should also not be overlooked is that fishing pressure, even if it was regulated, may have been greater than the relatively small striped bass populations could sustain, especially in combination with habitat effects.

## Restoration Stocking Efforts

The five Gulf coastal states, with funding assistance from the FWS and National Marine Fisheries Service, began efforts in the late 1960s to stock striped bass fry and fingerlings into coastal rivers to re-establish decimated populations. At about the same time, interest began to grow in establishing striped bass populations in inland reservoirs to control forage fish populations and provide trophy fisheries. This interest was bolstered by evidence of reproduction by landlocked striped bass in several reservoirs.

Although initially limited by fry availability, advances in spawning and culture techniques and large-scale fingerling production at national fish hatcheries allowed rapid expansion of this effort through the 1970s. Fish from Atlantic rivers were initially used to stock Gulf rivers and reservoirs, mainly due to the fact that much of the early work on large-scale artificial spawning was taking place on the east coast, and remaining native Gulf populations were at extremely low levels.

Over the years the availability of native Gulf fish for stocking efforts has increased, and essentially all stocking efforts in Alabama and Florida utilize native fish. However, substantial numbers of Atlantic fish are still being stocked in Louisiana, Mississippi and Texas and throughout the Mississippi River drainage.

## Other Management Efforts

In 1986 the GSMFC, in cooperation with the five Gulf states and federal agencies, developed an interstate fishery management plan for striped bass. The plan was amended in 1992. Although the goal of the FMP has not been reached, management efforts currently sustain limited recreational striped bass fisheries in coastal waters and lower river reaches in each Gulf state. Although Alabama allows striped bass taken from marine waters to be sold commercially, very little commercial harvest occurs due to their scarcity in coastal areas. For the most part, bag and length limits apply statewide in both salt and fresh waters.

## Gulf Race Striped Bass

In the late 1960s morphological differences between striped bass from the remnant Gulf populations and those from Atlantic rivers were discovered. The major difference was a significantly higher number of lateral line scales in the Gulf populations. Although this difference was found to be less pronounced following stocking of Atlantic origin fish into the Apalachicola system in the 1970s, molecular genetics studies subsequently found DNA markers that are unique to the Gulf populations. Recent studies indicate that introgression of Atlantic genes into the Apalachicola system has been minimal. You will hear lots more on striped bass genetics and taxonomy tomorrow. While there have been some indications that Gulf race striped bass may exhibit better condition than Atlantic race fish at higher water temperatures, significant advantages in growth, condition or survival have not been demonstrated in laboratory or field tests.

## Biological Considerations

Typical of anadromous species, striped bass in Gulf rivers move upstream during spring, congregating below dams in most rivers. Fish have been found in spawning condition from February to May, at temperatures generally between 57 and 68˚F. While evidence of natural reproduction has been found in all Gulf states, it is unclear to what extent it is supporting recruitment to the adult populations. The strongest contribution may be occurring in the lower Mississippi River, but the relative importance of this versus escapement from upstream reservoirs is uncertain. It is generally thought that Gulf striped bass fisheries, and perhaps the unexploited populations, would disappear without stock enhancement.

Since striped bass in the Gulf are basically a cool-water species trying to survive in a sub-tropical climate they seek the coolest water they can find during summer. They tend to avoid water temperatures above 77˚F, and actively seek cooler water, generally below 70˚F. This may be one of the most important limiting factors for striped bass in Gulf rivers.

After leaving summer thermal refuges, striped bass actively move and feed during fall, often going upriver again. During winter they tend to move to the lower river areas. While some go into bays and nearshore coastal waters, they are seldom found in open marine waters, which is a major difference with Atlantic populations, which exhibit the more typical anadromous pattern.

**Management Considerations**

Even though stock enhancement has re-established fisheries for striped bass in the undammed lower reaches of Gulf rivers and coastal areas, population levels have remained relatively low, and consequently angler interest has remained minimal. This fact influences the funding available for management and data gathering. Due to low angler interest, states are unwilling to use federal sport fish restoration funding for anadromous striped bass management. Prior to 1991 Gulf striped bass work was largely supported by a modest level of funding available through the federal anadromous fish grants. However, since that time the FWS has not been appropriated these funds. A very small amount is still available through the National Marine Fisheries Service.

It is generally believed that without continued stock enhancement, striped bass fisheries and populations in Gulf of Mexico rivers cannot be sustained. There is concern also regarding all Gulf anadromous species, the other two being the Gulf sturgeon and the Alabama shad. Perhaps future management should focus on all three species jointly rather than individually, as is currently being done. Restoration has mainly involved stock enhancement. Aside from efforts by the states of Florida and Georgia to enhance thermal refugia, and sporadic research in other areas, there has been no serious, focused effort to address habitat problems that may be limiting anadromous species in the Gulf.

**Where do we go from here?**

In the short time available I have only hit what I considered the major highlights regarding striped bass in Gulf rivers. I believe it has been an accurate portrayal. I invite clarification or corrections from anyone in the audience.

As Columbus pointed out, a major purpose of this workshop is to kick off efforts to revise the Gulf striped bass FMP. This will be an opportunity to reconsider our directions and strategies with regard to this species.

While we know a good bit about striped bass in the Gulf, there are still lots of questions that need to be addressed. We look forward to your input here and in a possible future workshop that will help us better define the questions and hopefully come up with some answers as we revise the FMP.

## Overview of Gulf States Marine Fisheries Commission Involvement in Striped Bass Management

*Ron Lukens, Gulf States Marine Fisheries Commission*

### Introduction and Authorities

The GSMFC is a compact of the States of Texas, Louisiana, Mississippi, Alabama, and Florida (west coast), which was formed by individual state enabling legislation and authorized by the U.S. Congress through Public Law 81-66, 1949. The mission of the GSMFC is ". . . to promote the better utilization of the fisheries, marine, shell, and anadromous, of the seaboard of the Gulf of Mexico, by the development of a joint program for the promotion and protection of such fisheries and the prevention of the physical waste of the fisheries from any cause."

In addition to the broad authority given to the GSMFC through the state and federal compact legislation, the GSMFC is authorized by Public Law 99-659, the Interjurisdictional Fisheries Act, to engage in the development of FMPs for species that are interjurisdictional in nature, meaning that they occur in more than one jurisdiction. Under this authority, the GSMFC has developed FMPs for a variety of species, including Spanish mackerel, Gulf menhaden, black drum, and blue crab, among others. The Gulf of Mexico Striped Bass FMP was finalized prior to the enactment of the Interjurisdictional Fisheries Act, but falls under the auspice of that Act and program for administrative oversight.

### Striped Bass Fishery Management Plan

In late 1984, the GSMFC Technical Coordinating Committee, the primary standing technical/science committee of the GSMFC, called for the formation of the Anadromous Fish Subcommittee. The charge given to this new subcommittee was to develop an interstate FMP for striped bass in the Gulf of Mexico. The Subcommittee immediately began work on the FMP, and in late 1986, the plan was adopted by the GSMFC.

Over the next several years, the GSMFC, through the Anadromous Fish Subcommittee conducted a variety of activities in support of the FMP. Those include the development of standard protocols for sampling all life stages of striped bass; a document entitled "Habitat Criteria for Striped Bass," which discusses the striped bass habitat suitability of several river systems in the Gulf of Mexico basin; a discussion paper which addresses the inequity of federal funding to support striped bass work in the Gulf of Mexico region; a variety of genetics projects; among others.

The Anadromous Fish Conservation Act (Public Law 89-304) contains a provision that provides for the states receiving 90% matching funds for striped bass restoration activities if they participate in an interstate FMP. In 1990, the National Marine Fisheries Service made a determination that the GSMFC Striped Bass FMP did not qualify under that Act, because the document did not contain regulatory recommendations. In response to that determination, the GSMFC undertook development of an amendment to the Striped Bass FMP to resolve the regulatory issue. By May 1992, Amendment 1 was completed and adopted by the GSMFC. That amendment contained three primary sections, including

- a description of the FMP development and adoption process,
- the establishment of uniform/compatible regulatory recommendations for management, and
- the establishment of a detailed action plan for research and data collection for striped bass.

**Pascagoula River System Activities**

The Pascagoula River system is thought by many to represent an ideal system in which to restore striped bass. That system historically had a naturally reproducing population of striped bass prior to the 1950s. In addition, the system has no man-made obstructions, such as dams or weirs, and water quality is good. Because of these attributes, the Pascagoula River system was selected by the Anadromous Fish Subcommittee as a high priority system for conducting demonstration restoration activities.

In 1997 and 1998, the GSMFC, using Federal Aid in Sport Fish Restoration funds, conducted a project to develop a geographic information system (GIS) database for habitat components of the Pascagoula River system. That database provides information regarding point and non-point sources of pollution, land use practices, and fishery related data in a map-based output. During that same period, again using Federal Aid in Sport Fish Restoration funds, the GSMFC conducted a temperature survey of the Pascagoula River system. That study sampled the Pascagoula, Leaf, and Chickasawhay Rivers, recording temperature at frequent intervals, and attempted to locate thermal refugia that might provide summer habitat for striped bass. The data from that study were provided in a GIS data file, and are included in the companion GIS database mentioned above.

**Funding Sources**

The Anadromous Fish Conservation Act was passed into law in 1967. The Act makes funding available to states to conduct research and management activities for anadromous fish species, such as striped bass, Gulf sturgeon, and Alabama shad in the Gulf of Mexico. From 1967 through 1990, the states in the Gulf of Mexico region received only 3% of the funding available, amounting to a total of approximately $3.3 million over 23 years. That amount has been insufficient for meeting restoration needs in the Gulf of Mexico. In 1991 the funding appropriated to the FWS under that Act was discontinued, and has not been reinstated. Currently, there is little support for anadromous fish restoration activities in the Gulf of Mexico from the Anadromous Fish Conservation Act.

The advent of the Federal Aid in Sport Fish Restoration Program established one of the most significant funding sources for state fisheries management in history. Many states have used their "Wallop-Breaux" apportionments to support striped bass work, including hatchery operations, stock enhancement, and creel surveys, to name a few. One of the difficulties related to using Sport Fish Restoration Program funds for striped bass is that their numbers are so few in Gulf of Mexico streams there is only a small constituency that recognizes striped bass as an available sport fish. Competition for Sport Fish Restoration Program funds is high, and often striped bass projects don't compete well, falling into a "catch 22" situation, where striped bass numbers have been low to non-existent for many years, so it is difficult to justify funding projects, and it is difficult to make any progress to increase the population numbers of striped bass, because there is little or no funding available to support projects.

Most recently, the FWS made funds available to several Gulf States from the Fisheries Stewardship Initiative Program. These funds, available for three years only, have been used to conduct monitoring and assessment projects in several river systems in the Gulf of Mexico. The primary purpose of the projects is to determine the current status of striped bass populations in the selected drainages. That funding will be discontinued at the end of June, 2000. With no dedicated source of funding to support striped bass or anadromous fish restoration in the Gulf of Mexico, ongoing activities to restore the species will likely be curtailed or discontinued.

This workshop is expected to provide the GSMFC and its member states with the most current status of striped bass in drainages in the Gulf of Mexico. In addition, the historical perspective provided by a number of invited speakers will allow the workshop participants to put into context the current state of knowledge, and provide a framework from which to make recommendations for future actions.

## Striped Bass on the Mississippi River

*Sidney Montgomery, TARA Wildlife Management and Services*

Well, I'll tell ya'll one thing, I would rather eat a worm then stand up here and talk to you guys. You are all experts in fish, and Pete and I are just country boys. We fish a lot, and somehow we've been better than most. Anyway, it is unusual that I am here, I guess, because for one I am not degreed in anything like you all are. The love of my life is the Mississippi River. All of my life I have fished and hunted around it, and it is probably one of the most intriguing and neglected bodies of water in the world. Starting as a kid I used to go water skiing with my brother, and I didn't care much about skiing so I would fish. My brother would ski and he would put me off on a sand bar on the river, which was the only place we had to ski or do that type of thing. As a kid in the early 60s I would take a Zebco 202 and worms and I would fish on the sand bars and catch a white bass, or a catfish, or whatever. My love for the River probably grew from those days. In the 60s I got a driver's license and bought a 12 foot boat and a 60 HP Evinrude. I would get honey buns, potted meat, and whiskey and I would go for an hour north of Vicksburg and just spend the weekend. Occasionally you would catch white bass and occasionally you would catch a black bass. In the 70s I started fishing a lot more seriously, and I bought a bass boat and fished all over. The River was still one of my favorite places, but back then you very seldom caught anything but catfish, and we would mainly tightline for catfish. We would also do a little jug fishing. On some of the dikes that were being built up there in Meyersville, you could catch a few white bass and maybe a crappie or black bass on occasion. When the dikes came into being we started fishing them pretty heavily and started catching white bass. We didn't catch any sea runs (striped bass), didn't even know what a sea run was back then. I think it was in 1987 that I caught my first sea run in the River. I told a friend of mine, Harry Barkley, I said Harry I'm catching sea runs stripes in the River, and he said there is no way. I said these are sea runs, I know what they are. So I invited Harry out there, and that day we caught 18 sea runs. From there on that was probably my main target fish when I fished the Mississippi River. In 1987 I caught 424 sea runs, in 1988 I caught 707, and in 1989 1,005. I don't have my logs from there on, but we are probably talking about averaging 2,000 sea run stripes a year, plus hybrids. I moved to Texas about that time and was unable to fish the River. I later moved back to take a job at TARA in 1994, and I started fishing the River again thinking this is going to be pretty neat, because with this progression of sea runs they are really going to be hitting. But I really had some poor trips on the River, and it is still that way, the stripes just never came back like they were. I wish I could recreate my logs, but at one time I did the math and I think I averaged about 27 searuns a day on the River, and now if we catch one or two, it is a good trip.

The Mississippi River around Vicksburg averages a mile wide, and places give us one full mile stretch that averages over a hundred feet deep. The dike pools are probably the best places to fish. I remember in 1987 I found a good dike called Marshall Point. I went that afternoon and I got into a lot of hybrids, and that afternoon and next morning I caught 104 hybrids that went from 3 to 9 pounds. The biggest searun we've ever caught in the river weighed 17 pounds. The biggest I ever caught was 14, but they will average probably 3 or 4 pounds each. The last two or three years they have been averaging about 7 pounds but these are generally older fish. Why they don't get big I don't understand, because in Ross Barnett Reservoir, which has a probably lower water temperature year round, we catch them up to 30 pounds, and 20 pounds plus is not uncommon at all. But in the Mississippi River you just don't get the big ones. I hear reports from people, you know fishermen are just notorious liars, including me, but the guys say man I caught one this one that must have weighed 40 pounds. I have yet to see one that big, 17 pounds is the biggest I've ever seen. I've made some notes here on my logs and in 1994 when I came back to Mississippi I fished 19 trips on the River, no I had 12 trips that year, I caught 19 searuns or hybrids, mainly searuns, and I caught 362 white bass. In 1995 I went 8 times and I caught 4 searuns and 165 white bass. In 1996 I went 20 times and caught 33 searuns and 1,023 white bass. In 1997 I went 18 times and caught 8 searuns and 583 white bass. This year I went 33 times and I caught 5 searuns and 758 white bass. And we catch saugers as well and other species, but the searun is my main thing. Also, the white bass fishing is just phenomenal. A funny thing about catching searuns, when I fished in the late 70s and early 80s, I fished for white bass and searun for a long time, and when the dikes first came into being I used the same technique that I use now to catch searuns and I never caught a searun until 1987. I had one day out there that they were really hitting, and I caught 152 searuns in one day. And white bass, of course they are a dime a dozen, a lot of times you can catch on an average day probably 25, and a good day you will catch up to 200. Though the River has made an improvement over the last few years, it still has a long way to go. You have so many industrial and commercial and farming interests, and they are all opposed to doing anything good for the River. It has been kind of the Nation's stepchild as far as waterways go, I think. And politics have always been on the side of the developer or money interests, and the Mississippi River has never been loved like I think it should be. It is really a sad situation because the fishery there is just about as good as it gets anywhere, and I have fished all the United States professionally for a number of years. I would rather go on the River than fish anywhere. You can catch them pretty much I would say May through December depending on water quality or water clarity. I have caught them with visibility of 3 inches and that has been about the muddiest it has ever been and still catch fish. A lot of time in the fall the River will really clear up and you can see 3 feet in the main channel, so it is not what you imagine. That's about all I have got to say about that, I've got some slides. One thing I found interesting this year that I haven't done a lot of it, is fishing for big catfish. I've got an X75 graph on my boat and also paper graph and a lot of these big eddies, especially the dike pools that have a point in the River with a big reverse eddy in the back filled with water, I have seen a lot of massive fish down there. They will be 3-6 feet long. This year there was a place, a kind of scoured bank reverse eddy that had a cave-in, and I turned my graph on, and the thing was filled up with fish. I mean, these were really big fish, probably averaging 4 plus feet long. So I caught some skipjack on one of the dikes, and these were probably 9-14 inches skipjack, and I started fishing some of these blowholes and, using 50 pound Spiderwire, I had it broken 5 times in one day. One of our guides was using a brown skipjack and ran a trotline. He had 1200 pound test, and he's had that broken twice out there. There is just some massive fish in that River, it is just incredible the size and the numbers of them. It is a totally neglected resource, on a good day you may see one or two other boats out there on the River, but as far as fishing goes it is just an experience that there is none other to compare it to. That Mississippi River is just a magnificent place. (Mr. Montgomery closed with a short slide presentation on Tara Wildlife)

# Recreational Fishing for Striped Bass in the Mississippi River Delta

*Pete Cooper, Outdoor Writer*

Let me begin by avowing I am not an expert striped bass fisherman, though I probably know much more about them than most southeastern Louisiana residents who are outside the scientific community. I have been quite interested in them - their history and their habits - for much of my life, I have assisted the FWS with growth-rate studies, and I have read volumes about them. And I have written and had published several magazine articles about them, specifically their presence in the lower Mississippi River Delta. To my knowledge the presence of striped bass in this area was first realized in the early 1960s.

At the beginning of my oil-field career in 1970, several co-workers related they had caught stripers from Bayou Lamouque which, I understand, was the first freshwater diversion system on the river and is located on the east bank between Ostrica and Pointe a la Hache. Some years later another oil-field worker who ran hoop nets for catfish in the main-line river told me that quite often during that period they would quickly fill up with stripers, which were of no commercial value at the time. He also said he dip-netted shad for bait at the Bayou Lamouque spillway and often accidentally netted stripers in that fashion. I had - and still have - no cause to doubt him: a present and very close friend has confirmed he and a few of his buddies fished for stripers with rod and reel in Bayou Lamouque during that time and occasionally caught fish weighing well over 20 pounds. However, several years ago both naturally occurring and man-made changes in the access routes to Bayou Lamouque seriously curtailed recreational fishing there, and I know of no one who has fished in it during the last decade.

During the mid 1970s it was discovered that a variety of popular saltwater species moved into the river and its passes when the water cleared in late summer and autumn. While fishing for them, large numbers of striped bass were occasionally encountered, not properly identified, and often retained in excess of the limit. These were small fish probably mistaken for white bass.

Prior to 1988 I personally saw only one striper over 15 inches long. However, catches of 20 or more a day were fairly common, and on two trips in one day I caught approximately 50. All were taken while walking along the rocks at Fort Jackson, and all were caught during August, September, or October. Frequently they were in association with white and yellow bass.

In 1988 the "Great Midwestern Drought" caused the river to drop and clear in May, and on the 23rd of that month, again while walking the rocks at Fort Jackson, I caught four stripers between 18 ½ and 21 inches long. But though the river remained clear throughout the summer, between that day and September 11 and on numerous trips, there were only infrequent encounters with small numbers of small stripers. From that point - September 11 to November 19 - and now mostly from a boat, I made nine trips, fishing from Pivach's Bend to the end of the Fort Jackson rocks and immediately downstream of Fort St. Phillip, and caught 25 stripers from 17 to 22 inches long and 10 smaller fish. Due to changing interests I have fished the rocks and the river very infrequently since then and have caught only a few more stripers in those places.

However, on October 17, 1989, I caught 11 of them from 12 to 16 inches long in Red Pass while walking along the Tidewater Road. And during the period of January 17-18, 1993, I caught three from 20 to 25 ½ inches long in the Buras Boat Harbor. One, 15 inches long, was taken there on February 19, and another of 20 inches, which showed hybrid characteristics, was taken there on March 7, 1994. Notably, that water is much higher in salinity than the river water is, and those fish were much chunkier and healthier looking than the river fish. Because of all that I froze those first three "saltwater" fish in their entirety and later transported them to the Louisiana Department of Wildlife and Fisheries main office in Baton Rouge for studies. Sadly, they were lost in a fire before they could be examined.

Besides the fish I have personally accounted for in various places around the lower river delta, I have witnessed others taken from different areas. In mid-summer 1993 a fish of approximately 18 inches was taken at the West Delta Block 25 platform which is a mile or so offshore of the mouth of the Tiger Pass jetties. Small numbers of stripers in the 18 to 22 inch class were taken during the last four years from the mid-reaches of Red Pass, Tante Phine Pass, and Grand Pass, and several of my fishing-guide friends have reported taking limits of similar-sized fish at the head of the Venice Jump to supplement their redfish and specks. And the spillway at Fort St. Phillip has been a hot spot for them for several years now. The largest striper I have personally witnessed - 31 inches long and weighing 10 pounds - was caught on October 21, 1995, in the main-line river just north of the head of Baptiste Collette. With the exception of the offshore fish, all were taken during the river's clear-water period of late summer and autumn.

Now, here are some observations:

(1) While stripers are assuredly present in the river year-round, virtually no one recreationally fishes in it during the muddy-water period which normally runs from late fall through mid summer. And although stripers may also be present year-round in deep, reasonably clear waters like the Buras Canal - which is assuredly the source of the fish I caught in the Buras Boat Harbor - very few of them are taken in delta waters other than the river. Why? For the same reason they are not caught in larger numbers from the river when it clears: most often the best tactics for catching stripers are not very effective for redfish and specks - the delta's most popular targets. Our folks fish for specks and reds, not stripers.

(2) While freshwater diversion systems have the potential for displacing stripers from the river into areas they have not historically inhabited, thermal stress in those waters - which are normally less than eight feet deep - will probably prevent them from surviving for any length of time. Indeed, thermal stress could be a reason for the lack of action in the river when it initially clears in late summer.

(3) Otolith studies have shown that stripers taken from the river and its passes exhibit very slow growth-rates, a probable result of the river's long-term turbidity which makes efficient feeding difficult. However, at one time there were big fish in the river as well as in Bayou Lamouque, and I have no reason to doubt there are still big fish in the river. Simply put, virtually no one has made an effort to learn how to catch them. In fact, I'd go way out on a limb and say that at present there is no directed recreational fishery for striped bass in the delta; they are almost entirely taken as incidentals.

(4) There has been some concern that the number of stripers in the river has been decreasing. I see no evidence of that or reason for it. A possible decrease in total catch may have resulted from an increase in angler-ability to catch specks and redfish there. In truth, the river continues to show a population of mixed age groups, 10 inchers to 22 inchers and larger, a result I've been told, of natural reproduction.

Whether or not that's the case, there is a worthwhile recreational striped bass fishery in the Mississippi River delta. While it has generally proven to be very seasonal and site-specific, late summer into autumn in the river, it is not completely limited to that particular time and place; fish have moved from the river into deep, high salinity areas which are possibly cool enough to allow them to survive indefinitely, though I would doubt those fish could make their way back into the river to spawn. In my opinion the striper fishery is largely underdeveloped and underutilized, mainly because it conflicts with specks and redfish. In other words, it's there, but most folks hereabouts could care less.

Stripers as incidentals - imagine that. Only in southeastern Louisiana. . .

# Cool Refuges for Big Striped Bass: Twenty Years of Testing the Thermal Squeeze Hypothesis

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## Introduction

The striped bass, *Morone saxatilis*, is a game fish that is important to the U.S. Gulf Coast. It is managed by the Gulf States Marine Fisheries Commission and Gulf Coast states (Nicholson et al. 1986). Once common, the species became rare in its native Gulf Coast range as human development of the region proceeded, particularly changes in the coastal river systems in which it resided. Although reasons for the decline are speculative, one candidate cause is the loss of cool temperatures believed needed by adults (Coutant 1985). This paper recounts the evidence from across the Southeast that large striped bass require cool water, and supports management efforts along the Gulf of Mexico to ensure continued presence of adequate thermal habitat. In particular, the paper reviews the cool-water hypothesis, reviews studies by Oak Ridge National Laboratory that developed and tested the hypothesis, reviews relevant studies elsewhere in the Southeast over the twenty years since the hypothesis was proposed, and relates these studies to management of Gulf Coast striped bass.

## Development of the Hypothesis

Basic studies of temperature selection by striped bass in the laboratory and field were initiated at Oak Ridge National Laboratory in the 1970s. Subadults (43-68 cm long) with temperature transmitters were followed in two enclosed rock quarries with adequate dissolved oxygen (DO) at all depths (Coutant and Carroll 1980). These fish occupied the warmest temperatures available at >1.5 m depth through spring and 20-24°C (centering near 22°C) in summer. In contrast, juveniles (8-30 cm) generally selected 24-27°C in summer in laboratory tanks and in a quarry lake (Coutant et al. 1984).

The first suggestions of a temperature-oxygen "squeeze" for large striped bass that preferred cool water came from telemetry studies of habitat selection in 12,222-ha Cherokee Reservoir, Tennessee (Coutant 1978; Waddle et al. 1980; Schaich and Coutant 1980). In retrospect, there were also hints from a telemetry study of Percy Priest Reservoir, another Tennessee reservoir (Stooksbury 1977). Initial results at Cherokee Reservoir indicated larger fish (> about 5 lb or 2.5 kg) were crowded into cool springs and small tributaries fed by pumping water from zinc mines during summer when reservoir temperatures were warm and deeper layers low in DO (Coutant 1978). Malnutrition and disease were common, and there were summer die-offs of larger fish in the main reservoir. No records of size structure of the reservoir population were available, but fish over 20 lb (9 kg) were rare.

Additional studies over two years (Waddle et al. 1980; Schaich and Coutant 1980) showed adult (4-10 lb or about 2-5 kg) striped bass selected the warmest temperatures available at 1-3 m depth in

March-May, and 15.5-25°C at depths of >8 m in June and early July. By late July, the fish avoided hypolimnion oxygen <3 mg/L and temperatures generally >22°C and moved to cool (15-25°C), oxygenated (>5 mg/L) springs or creek channels (refuges). Some fish made excursions into the main reservoir at temperatures up to about 25°C. Fish moved out of refuges in autumn when reservoir temperatures approximated 22-24°C. Older striped bass preferred cooler temperatures (16-20°C) than younger sub-adults (20-23°C). The importance of cool temperatures for reproductive success was demonstrated by comparing hatchery production records for brood stock collected from three reservoirs, one in which striped bass were temperature/oxygen stressed (Cherokee) and two not stressed (Watts Bar and Norris reservoirs)(Coutant 1987b).

This work was used by Coutant (1980, 1985, 1986, 1987a) to synthesize a thermal niche hypothesis for striped bass. Coutant (1987a) described the changing thermal niche as striped bass grow and illustrated the effects on habitat selection by two reservoirs in series. This work stimulated a survey of other reservoirs in the Southeast that documented common summer die-offs of large striped bass (Matthews 1985).

Hybrid bass (striped bass x white bass) were also present in Cherokee Reservoir but they were not studied in detail. Incidental observations indicated they did not exhibit the signs of stress shown by striped bass. No mortalities of hybrids were observed.

**Testing of the Hypothesis**

Additional studies of striped bass habitat selection have been conducted by researchers at many locations across the southeastern U.S. The hypothesis has been generally confirmed and expanded upon.

In Watts Bar Reservoir, Tennessee, Cheek et al. (1985) found that 24°C and DO concentrations of about 4 mg/L appeared to determine the spatial distribution of adult striped bass (2-13.5 kg, av. 6.3, or 4.4-29.7 lb, av. 13.9) fitted with transmitters. During winter and early spring when temperature and DO were vertically and horizontally uniform, striped bass were mobile and widely distributed. As the reservoir warmed in summer, fish were less mobile and were progressively limited to areas in tributary arms where temperature was less than 24°C (av. 20°C, SD 2.1) and DO exceeded 4 mg/L. Notable congregations occurred in hypolimnetic discharges in the tailwaters of upstream impoundments and groundwater inflows. Striped bass were restricted to these areas until fall cooling. There were no die-offs reported, apparently because of abundant cool refuge space.

Adult and subadult striped bass in Alabama began to concentrate in cool thermal refuges in summer when ambient temperatures approached 27°C (Moss 1985). In the Alabama River, Lake Jordan, and Millers Ferry Reservoir, striped bass tagged with transmitters sought refuges in cool (near 26°C) tributaries, although they would move for short periods of time (hours) through reservoir temperatures of near 30°C. Transmitter-equipped fish weighed 2.7-7.1 kg (5.9-15.6 lb). Fish in refuges in summer had lower condition factors (weight for a given length) than fish outside refuges in spring. Further studies by Lamprecht and Shelton (1986) on 5-9-yr.-old fish in this system confirmed that adult striped bass preferentially occupied the Thurlow Dam tailwater (Tallapoosa River; maximum temperature 24°C) rather than the adjacent lower Coosa River (maximum temperature 33°C). The fish tended to select the Tallapoosa River in spring when temperatures were 16-17.5°C and depart at 19.5°C (1981) or 18.5°C (1982).

A series of studies on Lake Texoma, Oklahoma/Texas, has helped define the seasonal habitat selection of striped bass of different size classes in this southeastern reservoir (Summers 1982; Matthews et al. 1985; Matthews et al. 1989). Summers (1982) first reported that large striped bass tagged with ultrasonic transmitters congregated in the lower lake in summer. This region is known to have intense thermal stratification and low oxygen to anoxic conditions in the hypolimnion. Matthews et al. (1985) used echolocation to chart the vertical distribution of fishes (including subadult and adult striped bass) in the reservoir. In May and June, before stratification, fish in the main reservoir were distributed top to bottom. With the onset of stratification and oxygen depletion, fish moved upward avoiding the anoxic conditions (<2 mg/L) near the bottom and downward from the surface. In July and August, most fish occupied zones just above where oxygen was depleted and where temperatures were near 28°C. Surface temperatures at that time were 28-30°C. Despite being exposed to temperatures higher than 25°C, there were no apparent mortalities of striped bass.

Matthews et al. (1989) reported on a large, multi-year gill netting study of seasonal striped bass habitat use at a mid-reservoir location in Lake Texoma where different size groups exhibited different patterns of seasonal abundance. Large (>5 lb. or 2.27 kg) striped bass were never found in summer when temperature exceeded 22°C. Medium-sized fish (3-5 lb. or 1.36-2.27 kg) showed lower abundance when temperatures exceeded 22°C than when it was cooler. Small fish (<3 lb. or 1.36 kg but not young-of-the-year) were collected abundantly up to 29°C but catches diminished markedly at 30°C. The authors felt their data confirmed the thermal niche hypothesis of Coutant (1985) with one exception. Large striped bass in Lake Texoma were able to survive temperatures above 25°C, as shown in the authors' earlier study (Matthews et al. 1985). Their gill netting results were consistent with adults moving to the lower lake where large numbers were concentrated just above the anoxic hypolimnion (12 m) in temperatures near 28°C and DO of 4 mg/L. The authors state that "adults seem to be sharply influenced by intolerably high temperatures throughout the water column in uplake areas, which they abandon in summer." Small fish, however, thrived in the warmer water, a response which the authors related to the temperature-growth relationships published by Cox and Coutant (1981).

Temperature-related behavior of striped bass was studied by Braschler et al. (1988) in the freshwater system in which striped bass were first recognized to be successful under landlocked conditions, Lakes Marion and Moultrie, South Carolina (Santee-Cooper Lakes). These lakes are not stratified in summer, with surface temperatures approaching 30°C and a small (<3°C) surface-to-bottom gradient. Dissolved oxygen concentrations were nearly always above about 4 mg/L. Adult fish (2.5-8 kg; 5.5-17.6 lb) tagged with temperature-sensing transmitters generally occupied the coolest water available in the summer vertical gradient in the lower reservoirs. They moved to restricted areas of springs, sink holes, and creek beds when temperatures exceeded 28°C. However, refuges where fish were found were only 0.3°C cooler than nearby bottom temperatures and 1°C cooler than average water column temperatures. Because the population appeared to be thriving, the authors concluded that striped bass adults can tolerate water temperatures in excess of 28°C if adequate dissolved oxygen is present.

Hampton et al. (1988) tracked ultrasonic-tagged adult striped bass less than 4.5 kg (10 lb.) in well-mixed Wilson Reservoir, Kansas, which had a thriving population of stocked striped bass. Fish in summer generally occupied mid-depths near the dam, with little movement. Temperatures were above 25°C from mid-July to mid-August, and reached 27.1°C. Dissolved oxygen was always high at all depths. There were no apparent cooler thermal refuges. The paper did not indicate sizes of striped bass in the reservoir, and it might be assumed that the tagged fish were typical of available larger fish. If so, the fish, stocked since 1965, attained only small sizes.

Adult striped bass (3.2-8.6 kg; 7-19 lb) were tracked in Lake Whitney, Texas, by Farquhar and Gutreuter (1989). Summer distribution was limited to near the dam, where temperatures occupied were as high as 29°C. Summer mortalities had occurred but not in the year of this study. Fish were generally in the coolest water available in summer (27-29°C) that contained DO of >4 mg/L. The mean temperature of water occupied by fish with thermistor-implanted tags in July 1983 was 27.0°C. In early September, the cool water was depleted by water withdrawals and the reservoir became nearly isothermal at 28-30°C, which lasted until cooling began in late September. Fish then dispersed from the zone of summer concentration. In winter they aggregated near 7.4-8.8°C and were widely distributed the rest of the year.

The distribution of four size groups of striped bass was studied with telemetry in Old Hickory Reservoir, Tennessee, by Poarch (1989). The smallest size group (1.8-4.9 kg; 4-10.9 lb) was distributed through the lower reservoir in summer. The other three size groups (up to 14.5 kg or 31.9 lb) were attracted to cool tailwaters (<23°C) of two upstream dams. The largest size group was consistently closest to the dams in the coolest water. Groups of progressively smaller fish sizes were distributed at increasing distances downstream in increasingly warm water. Average temperatures occupied were 20-21°C, with those above about 24°C nearly always avoided (reservoir temperatures reached 32°C). In spring, movement toward tailwaters began near 20°C. Poarch (1989) pointed out the similarity in geographical separation of sizes in Old Hickory Reservoir to that seen in coastal waters, e.g., by Chapoton and Sykes (1961) and Clark (1968). Coutant (1985) had attributed that separation in coastal waters, in part, to differences in temperature preferences.

Zale et al. (1990) monitored habitat selection by adult striped bass (>500 mm total length, probably 2 kg or 4.4 lb or larger) using gill nets in 10,600-ha Keystone Reservoir, Oklahoma, where summer mortalities are common. An earlier study there (Combs and Pelz 1982) had identified movement of tagged adult striped bass to midwater zone near the dam in summer. During summer of the Zale et al. study, striped bass were restricted to a thin layer (1-2 m) in the stratified water column consisting of the coolest water available where DO exceeded 2 mg/L. Fish stopped feeding when minimum oxygenated temperatures reached 27°C. Lochmiller et al. (1989) concluded that the fish suffered high temperature stress and had nutritional problems. No mortality occurred in 1986 when temperatures in the oxygenated layer reached 28°C and were above 27°C for one month. Mortality did occur in 1987 when temperatures peaked at 29.3°C and remained above 27°C for one month and in 1988 when temperatures peaked at 28.3°C and remained above 27°C for about 7 weeks. Mortalities continued after suitable water quality conditions returned. The authors suggest that adult striped bass can tolerate exposure to 27-28°C for about one month but die (probably of malnutrition) when exposed to higher temperatures for a similar period or when exposure to 28°C is prolonged. This study is notable for explicitly considering the duration of summer exposure to high temperatures and hypothesizing a temperature-dependent nutritional point-of-no-return that signals mortality, either immediate or delayed. It suggests that the high temperatures apparently tolerated in Lake Whitney, Texas (Farquhar and Gutreuter 1989) may have been too short a duration for mortalities to occur, even if they were detrimental. Although adults, the fish studied were small in relation to sizes attained in cooler waters.

Striped bass from the coast of the Gulf of Mexico appear to show similar influences of temperature on seasonal distribution (Van Den Avyle and Evans 1990). In the Flint River-Lake Seminole portion of the Apalachicola River system, the fish (3.2-30 kg av. 14.1; 7-66 lb, av. 31) ranged widely through the system in fall, winter and spring. During summer, however, they occupied cool refuges exclusively, entering when surrounding water temperatures averaged 24.3°C (23-25°C) and remained there until October or November when ambient temperatures declined to an average of 20.1°C (17-23°C). Temperatures selected by the fish averaged 21.6 during two summers, with an avoidance temperature of about 23°C.

Twenty-four adult striped bass 4-9.1 kg (8.8-20 lb) were fitted with transmitters and tracked in the Ohio River (McAlpine Pool) for one year by Henley (1991). Water temperatures >27°C were recorded in the non-stratified pool from 11 July until 15 August, when fish concentrated in the tailwaters of upstream Markland Dam or in slightly cooler tributaries. Four (the largest) died during this period of obvious physiological stress.

Large striped bass in the St. Johns River, Florida, were in poorer condition in summer than in winter (McDaniel et al. 1991). This situation was attributed to thermal stress, in accord with observations by Coutant (1985) and others. No seasonal differences in condition were observed for smaller-sized fish.

Adult striped bass in Albemarle Sound, North Carolina, were studied in the summers of 1993-94 (Haeseker et al. 1996). Thirty-six of 78 transmitter-equipped fish (>50 cm total length, 2-3 kg or 4.4-6.6 lb) successfully roamed the Sound in summer at minimum recorded temperatures above 25°C between mid-June and early September and near 29°C in July. There was a high mortality level. Dissolved oxygen levels were always adequate, and no clear thermal refuges were identified. Fish sought the deepest (and probably coolest) depths during the warm periods. In collections of other striped bass, those 32.5 cm total length or longer were in relatively poor condition, with low weight in summer, and exhibited extensive occurrence of red dermal lesions and external parasites. Condition worsened through the summer, but few mortalities were observed. Smaller fish appeared in normal condition during the whole period, consistent with the changing thermal requirements as striped bass grow (Coutant 1985).

In Kerr Reservoir, Oklahoma, adult striped bass in two groups (< 2.4 kg or 4.8 lb and >2.9 kg or 6.4 lb) exhibited a distinct summer "thermal refuge season" (Wilkerson and Fisher 1997). The transmitter-equipped fish remained in the Illinois River tributary where temperatures were cool because of upstream hypolimnetic discharge. Fish moved to the restricted refuge when temperatures were >22°C and left at 14-22°C.

Hybrid bass (striped bass females x white bass males) occur in the Gulf Coast drainage and have generally higher temperature preferences than striped bass. Hybrids are usually smaller than striped bass for a given age after the first year. Windham (1986) used telemetry to follow 31 hybrids about

0.9-1.9 kg (2-4.2 lb) in Clarks Hill Reservoir, Savannah River. There, selected temperatures ranged 20.5 to 29.3°C with a mean of 26.3°C in July - September. There were strong thermal stratification and low oxygen in deeper waters. Tagged fish tended to reside just above the thermocline. Stocking programs for enhanced fisheries have tended to shift to use of hybrids in waters where striped bass have encountered limited summer habitat because of high temperature and low dissolved oxygen (Axon and Whitehurst 1985; Windham 1986).

Effects of temperature on juvenile growth rates of both striped bass and hybrids have been studied in the laboratory and illustrate the differences in temperature responses between striped bass and hybrids. With ample food, maximum growth of juvenile striped bass occurred near 24°C; zero growth occurred at 33.5°C (Cox and Coutant 1981). Comparable data for hybrid bass were 27.9°C and >34.5°C (Woiwode and Adelman 1991). Hybrids continued to feed at a lower temperature (6.5°C) than striped bass (10°C) in these studies, further supporting the wider general temperature tolerance (eurythermy) of the hybrids.

Habitat restriction for striped bass in summer can be both a boon and bane for anglers. Clearly, the attractiveness of restricted habitat of a dam tailwater or spring for large striped bass in summer has benefitted anglers in contrast to the too-warm water elsewhere. The large fish have concentrated there and anglers know how to find them. Therefore, there is a great fishery. This phenomenon has been documented by several state fish and game agencies (e.g., below Melton Hill Dam on the Clinch River arm of Watts Bar Reservoir, Tennessee; Cheek et al. 1985). Habitat restriction such as a limited depth distribution in reservoirs as seen by several authors, or springs and cold streams seen by Waddle et al. (1980), Schaich and Coutant (1980), and Cheek et al. (1985), is beneficial to anglers if the fish were not too warm or otherwise stressed to feed and the anglers can find them. Conditions must be reasonably good for fish and the anglers must be able to find them for there to be a good fishery.

For a fish population subject to an active fishery, the combined physiological effects of summer conditions and angling stress need to be considered (at least for fish caught and released or not landed). Tomasso et al. (1996) determined that striped bass <36 cm total length caught on hook and line exhibited physiological indices of stress in summer (26-32°C) but not in winter (16-19°C). Mortality was also higher in summer. It seems a reasonable interpretation of this study to conclude that striped bass caught from temperatures above those preferred will have higher stress and mortality than those caught from preferred temperatures.

The hypothesis that large striped bass need cool temperatures has been amply supported by over twenty years of field studies in Southeast reservoirs and rivers. There is a strong interaction with low DO in reservoirs, such that there is a "temperature-oxygen squeeze" in summer that restricts suitable habitat. Successive studies have increased our knowledge of the ability of large striped bass to tolerate high temperatures (well above preferred) and low dissolved oxygen levels for short periods in summer. Enough of this work has been carried out in Gulf coast waters for a reasonable conclusion that Gulf fish respond similarly to striped bass in other locations and are subject to the same habitat restrictions.

## Application to the Management of Gulf Coast Striped Bass

It is important to recognize the riverine orientation for striped bass populations along the Gulf coast. This is a trait shared with striped bass in most of the East Coast south of Cape Hatteras, and especially those from Georgia to central Florida. This riverine nature is likely the result of the intolerance of adults for high coastal temperatures in summer. Rivers are the large thermal refuge in summer for fish that may use coastal waters at other times. Thus, cool rivers are essential for continuation of the striped bass as a Gulf coastal species. They need to remain (or be restored as) cool, unpolluted, and unimpounded near the coast.

At a more local scale, we know that coastal rivers are not uniformly cool. They probably never were, and certainly are not now. However, sufficient research has been carried out on striped bass in Gulf coastal rivers to recognize that these rivers have cool places in summer, usually groundwater springs but more recently cold dam tailwaters, also. These springs probably provided the summer thermal habitat that allowed striped bass to continue its existence along the Gulf coast as the climate warmed at the end of the last glacial period. Now the cool dam tailwaters are providing similar localized habitat.

Successful management of striped bass along the Gulf Coast will require protection of thermal refuges for large, reproductive-aged striped bass. This will mean protection of the physical integrity of refuges (preservation of groundwater flows, restriction on riverbank development in locations that would destroy a refuge, avoidance of impounding river reaches with refuges, etc.) and restriction of harvest of fish that are concentrated in refuges and prime targets for anglers. Where dam tailwaters are now providing major refuges, these dams need to be operated in ways that maintain the cool temperature releases in summer, particularly after they have attracted large striped bass. As studies elsewhere have shown, it is the largest striped bass that are the most sensitive to high temperatures. Therefore, the most stringent efforts to protect refuges will be necessary where the largest, trophy-sized fish are a prized resource. Otherwise, the species may be sustainable, but the population will consist of small individuals.

Although the reasons for the decline of Gulf coast striped bass were unclear and speculative in the early 1980s (Nicholson et al. 1986), an extensive literature review since that time has established cool temperatures as a critical need for large striped bass that probably was not being met adequately. Now we have the understanding to develop habitat and fish management strategies to improve the likelihood that this requirement can be met.

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**QUESTION (Rick Slack):** What is a high DO?

**ANSWER:** Well, we've looked more at the temperature side of the picture than we have the DO picture and generally the fish seem to be doing really fine if it is 5 parts per million or above. We have never seen, in the telemetry work that I've done, any hint of restriction above 3 or 4 parts per million. Some of those excursions that I showed actually went down to 2 parts per million, and that is why we picked that as the level.

**QUESTION (Rick Slack):** Let me restate that. Right at the very end you were summarizing that they can survive higher temperatures when DO is higher. What level might you call a higher level?

**ANSWER:** I wish we knew. As I say, we just don't have too much quantitative data on it. Five parts per million, which the states have accepted as standard, seems to be reasonable. If you could really oxygenate the water, to the point where you could get it up in the summer to super saturation levels of 8 or 9 parts per million, you might do better. I don't know. It is a good topic for research.

**QUESTION (Charles Mesing):** In reference to his question, you might see some of that in some of these reservoirs with discharge water during the summer months. These larger fish tend to go to those areas when you think they are too large to be in turbulent water. The question I have is related to salt. A good hatchery man will tell you if you have some stressed stripers, you throw a little salt on them and they will do better. Do you have any lab evidence that salinity in the water, as in coastal areas, may elevate temperature tolerance?

**ANSWER:** The best study, comparable to what we have done in fresh water, was the Albemarle Sound work. They had fish going essentially through the same process at the same temperatures and DO. Their temperatures got up to 28-29, and the fish were getting skinny and showing disease problems too. From that study we say there probably isn't much difference when it's saline. Now Albemarle Sound is brackish, it is not really saline. I've done a lot of looking at Chesapeake Bay. One of the arguments I've gotten up there is that all their fish don't do this. They may do it in your southern reservoirs, but they don't do it in the Chesapeake Bay. Well, the pattern fits what we see in the reservoirs, they don't see the mortalities, but then it is a huge system and finding dead fish is probably more difficult. The fish do have the opportunity, the biggest ones, to leave the bay and go to the coastal waters, which they obviously do and there are lots of good records for that. So, with that kind of a scanty evidence, I'd say probably the same things are going on. There may be a little advantage to fish in salt water, but we haven't been able to quantify it.

**QUESTION (Laura Jenkins):** You said that in warmer water the fish are smaller. Are there instances of survival where a small pocket of them find that cool water and reproduce?

**ANSWER:** Actually, some of them are reproducing in smaller sizes too. Of course we confuse that by all the stocking work we've done. I mean, we've done good things with the stocking, but in terms of being able to see what the effects of natural reproduction are, we have messed up the picture with stocking. I conducted a hatchery study with fish from Cherokee Reservoir where they were stressed and another reservoir where they were not stressed. Using the standard hatchery practice of reproduction, Cherokee fish just did terribly. They had cool water and were locked up in refuges, so even big fish stuck in refuges in the summer may not be very reproductively competent. So I would say that any situation where we force these fish into a dense refuge where there is low food supply, we are going to have problems with natural reproduction. It is probably just stocking that is sustaining the population. But, again, we don't have sufficient quantitative evidence.

## Prescribing Fish Hatchery Production Objectives for Optimum Stock Enhancement: A Case History with Restoring Striped Bass in the Savannah River

*Mike VanDenAvyle, Biological Resources Division, U.S. Geological Survey*

ABSTRACT:

Hatchery production objectives have often been viewed as constraints rather than components of fishery management efforts. In many cases, the lack of knowledge of fish performance in receiving waters has impaired the development of clear objectives for hatchery production, essentially decoupling management into separate "hatchery" and "post-stocking" phases. This separation often prevents optimization of the overall management effort. In a study of post-stocking survival of striped bass in the Savannah River, GA/SC, the relative cost and survival of three size classes of hatchery-reared fish were evaluated during 1990-1996. Based on per-fish production cost, stocking of the smallest size class (phase I, 20-35 mm TL) would have been recommended. However, by adding information obtained for estimated survival of fish at 48-hours post-stocking, it was concluded that the intermediate size class (advanced phase I, 60-80 mm) was superior. However (again), by adding information about survival of stocked fish to age 2, the largest size class (phase II, 175-250 mm) was considered optimal for future stocking efforts. Differences between conclusions reached at various points in the rearing-stocking chronology indicate the sensitivity of management decisions to the type of information available and the need for comprehensive information to allow a (seemingly) correct decision. In this case, recruitment to the adult stock was optimized by stocking fewer, larger, more costly fish, and the findings were incorporated into hatchery production objectives.

**QUESTION (Ron Lukens):** Mike, did you use the cage studies to imply survival, or is that just an adjustment?

**ANSWER:** Our initial reasoning for the cage studies is that we wanted to have what we felt was an accurate count of the real number of fish that were being stocked out of each truckload. Based on what was in the literature from other work, we didn't expect that the percentage that would die in each truckload would be the same, i.e. there would be lots of variation. We wanted to get a better handle on that, so that is why we implemented the cage studies. One thing I didn't go into, is that the fish get handled a lot in the harvest and delivery process, and they do a lot better, at least for the first 48 hours, than if you stock them into fresh water,.

**QUESTION (Ron Lukens):** Did you take the percent mortality in your cages, your 48 hour cage study, and apply that to the number of fish stocked?

**ANSWER:** Yes, and that was used in the comparison with later catch rates.

**QUESTION (Howard Rogillio):** Did you hold phase 2 fish in your 30 gallon containers?

**ANSWER:** Yes, for the advanced phase 1 fish, we put 30 fish per 30 gallons, and for the phase 2s we put 10 fish per 30 gallons.

**QUESTION (could not identify the speaker):** Is your shocking time the actual time the current was applied?

**ANSWER:** Yes, I showed metered peddle time.

**QUESTION (Charles Mesing):** The larger fish were tagged, is that correct?

**ANSWER:** In 1990 some of the fish were tagged with internal anchor tags. Thereafter, the larger fish were tagged with micro tags and with OTC (oxytetracycline).

**QUESTION (Charles Mesing):** Does it matter to you whether the mortality occurred from the tagging or from the cages? Could you determine the source of mortality?

**ANSWER:** Well we'd like to think that the estimation does take that into account; although, we are not able to tease out all of the sources of variation. We did some other work that I didn't present where we went backwards and looked at stress levels of fish when they went into the cages and then 48 hours later. The larger fish didn't do real well in those cages. What we found was that the greatest explanation of variation of the 48 hour survival for a given size group was the condition of the pond when it was drained. If it was a weedy, muddy mess, the fish did poorly two days later when they were put in the river.

## Lake Texoma Striped Bass Fishery Update

*Paul Mauck, Southcentral Region Supervisor*
*Oklahoma Department of Wildlife Conservation*

Even though Lake Texoma is more than 50 years old, and under normal lake trends should be on the downhill slide in fish production and angler use, it seems to be getting better than ever. Few lakes in Oklahoma and Texas can match the angler use and recreational activity that Lake Texoma receives. So what makes Texoma such a unique angler paradise? The tremendous diversity of fish species inhabiting the impounded waters of the fertile Red and Washita River systems is the key. Texoma continues to maintain one of Oklahoma's best striped bass, white bass, largemouth bass, spotted bass, smallmouth bass, and blue catfish populations. The backbone or supporting structure for this tremendous biomass of sport fish is the abundance of a diverse forage fish base. Threadfin and gizzard shad continue to abound in its productive waters, but are accompanied by freshwater drum and a host of other freshwater minnow species that provide food for the sport fish populations. The saline waters of the Red River system contribute to the well-being of the fishery, since it is an important element that allows the red muddy water to settle out to the blue, productive water that appeals to fish and people alike.

Economic studies conducted on the lake during the past decade indicate that the fishery contributes $20-25 million annually to the economy of the area. During the last ten years the lake received from 400,000 to 600,000 angler visits annually, with six out of ten anglers fishing the lake seeking striped bass.

Creel studies conducted in 1997 by the Oklahoma Department of Wildlife Conservation and the Texas Parks and Wildlife Department indicated that in excess of 875,000 striped bass weighing a total of 1.9 million pounds were harvested from the lake in that year. If managed properly, this renewable resource is capable of this type of production year after year.

Since the lake is situated in both Oklahoma and Texas, biologists from both states have joined together to monitor and manage the enormous fishery. Numerous research projects have been made possible by using Sport Fish and Wildlife Restoration funds which have allowed conservation agencies to keep abreast with the changing fish population dynamics but also implement fisheries management activities that enhance fishing. Not only has the introduction of non-native fish species (striped bass, Florida strain largemouth bass and reservoir strain smallmouth bass) made a positive addition to the native fishes, but a water level manipulation plan operated by the U.S. Army Corps of Engineers, conceived and endorsed by the Lake Texoma Advisory Committee, has enhanced fish spawning and nursery grounds and more than doubled black bass production over the past seven years. Manipulation of water levels also allowed Japanese millet to be aerially sown in the upper reaches of the lake to promote greater waterfowl utilization in the fall and winter. Thirty-eight marked fish attractors have been developed and maintained in all major coves in the Oklahoma portion of the reservoir to assist anglers fishing for crappie and other sport fishes. To determine the desires of anglers using the lake, an Angler Opinion Survey was conducted by Texas A&M University with Sport Fish Restoration funds during 1997 to gain insight in various parameters of how the fisheries of the lake are being and should be managed. Creel and fisheries surveys are conducted each year to monitor fish populations and angler use of the fishery. Synchronized fishing regulations were imposed on January 1, 1998 to make all length and creel limits the same in Oklahoma/Texas waters.

What does all this add up to? It all makes for one of the greatest hot spots and economic sources this region of the country has to offer.

**QUESTION (Chuck Coutant):** You indicated that the harvest is made up of a lot of small fish. Have you considered harvesting more of the little ones to give more space to grow up to be big ones?

**ANSWER:** We had a 15 fish bag limit, the most liberal limit in the whole country, and it didn't make any difference. So I think that increasing the bag or reducing the size limit will not have a positive effect on increasing the number of larger fish.

## Santee-Cooper Reservoir Striped Bass

*Jim Bulak, South Carolina Department of Natural Resources*

I want to thank the U.S. Fish and Wildlife Service and the Gulf States Marine Fisheries Commission for inviting me to this workshop.

The South Carolina Department of Natural Resources (SCDNR) has monitored the Santee-Cooper striped bass fishery for nearly 40 years. In the last 15 years, research efforts have increased. I will quickly summarize points that may be applicable to the Gulf restoration effort. In South Carolina, our current management strategy states that, in waters with successful natural reproduction, we will manage with harvest and stocking strategies that provide optimal harvest and maximize the possibility of conserving self-sustaining, genetically-diverse populations.

The Santee-Cooper Lakes, Marion and Moultrie, were impounded in the early 1940's and encompass 170,000 surface acres. This was the first inland, land-locked location where successful natural reproduction of striped bass was documented (Scruggs, 1957). In the early years of impoundment, the striped bass population flourished and a boom fishery existed (Stevens, 1958).

Natural recruitment of striped bass in Santee-Cooper declined drastically in the late 1970's. Prior to this time, hatchery augmentation of the population was not needed. So, the question was, "What was happening with recruitment?" This recruitment decline stimulated research.

Initial research efforts focused on quantifying the level of egg production in the Congaree and Wateree river spawning tributaries. Earlier, May and Fuller (1965) had quantified egg production and reported that the Congaree River was the main spawning tributary. In the 1980s, egg samples were taken as frequently as every 3 hours to quantify the level of egg production. This level of sampling was required to account for the highly variable occurrence of eggs. Bulak et al. (1993) reported an average of 18.4 billion eggs were spawned in the years 1988-90. From these egg production estimates and concurrent estimates of length-frequency distribution and fecundity, SCDNR was able to estimate the number of spawning size females in the population.

Striped bass are a highly fecund (Lewis and Bonner, 1966), long-lived fish. A 15 pound female lays over one million eggs each year and striped bass can spawn in approximately 15 different spawning seasons. This translates to a lifetime production per individual of over 15 million eggs. If the population is in equilibrium, only two out of that 15 million eggs per female would survive.

Understanding the factors in a system that increase the survival potential of a cohort of eggs is essential. Thus, in a cooperative study with the U.S. Geological Survey (Hurley, 1991), equations were developed that allowed the prediction of spawning and hatching locations from water temperature, flow, and egg age information. Due to generally lower temperatures and higher flows during the early part of the spawning season, eggs have greater probability of transport to Lake Marion prior to hatching. As the spawning season progresses, temperatures increase and flows tend to decrease, leading to more hatching of eggs in the spawning tributaries of Lake Marion.

Egg studies helped document the influence of dams on spawning and hatching of eggs. Studies suggested that lowered dam releases can increase the probability of a spawning event by increasing the rate of warming of the river. Lowered flows will also affect the spawning location of an egg. Based on this information, SCDNR has worked with the hydropower operators to develop release schedules that would maximize recruitment potential.

For more than 30 years, SCDNR has conducted juvenile surveys to monitor striped bass recruitment. In recent years, we aged juvenile otoliths to determine the age, in days, of surviving 50-60 day old fish. This allowed us to determine which spawning cohorts produced the highest relative survival rates. For example, in 1990, a strong recruitment year, peak survival of juveniles occurred very early in the spawning season. During each spawning season, zooplankton density and species composition were also assessed. In general, we found that in good recruitment years, there was an order of magnitude increase in zooplankton abundance during the spawning period. We concluded that eggs hatching at the right time in or near Lake Marion, where there is the greatest potential for zooplankton production, have the greatest probability of producing recruits (Bulak et al. 1997).

So, what effect are fishermen having on recruitment? From winter gill-netting, abundance data, we were able to generate catch curves. Initial estimates of total mortality, once striped bass entered the fishery at age-2, were 60% per year. Since females don't fully mature until age-5, approximately 90 percent of females were taken from the population before they had a chance to spawn for the first time. After this initial assessment, SCDNR changed its regulations. We now possess a 5 fish per day bag limit and a 21 inch (i.e. age 3) size limit. An alternative recommendation was to increase the size limit to 24 inches (i.e. age 4) to further increase spawning potential (Bulak et al. 1995).

The effects of stocking on the population have been considered. Beginning in the 1980's, we have stocked approximately two million striped bass fingerlings each year into the Santee-Cooper reservoirs. All stocked fish were marked with oxytetracycline (OTC). The initial two years of data indicated that 85% of the fish that reached age 2 were of hatchery origin. We became concerned that our hatchery actions were genetically 'swamping' the population. However, two of three of the next years had relatively strong natural recruitment and the five year average indicated about 50% of age-2 fish were of hatchery origin. Further genetic assessments indicated effective population size ranged from approximately 10 in poor recruitment years to greater than 100 in good recruitment years (Diaz et al. in press). As a result of these studies, hatchery production efforts currently have a goal of using a minimum of 30 different females each spawning season. If we use 30 females each season, analysis indicates the hatchery is helping genetic diversity in poor recruitment years

We have also assessed the status of smaller, naturally reproducing populations in our coastal rivers, such as the Combahee River. An initial question was whether these populations should be augmented with brood fish from the Santee-Cooper system. Genetic assessment indicated that coastal river populations were reproductively isolated from the Santee-Cooper population, indicating genetically distinct populations. Tagging data supported genetic data, showing that nearly all tagged striped bass were recaptured in the river in which they were tagged. Based on the this information, coastal river populations are now augmented with endemic brood stock. From tagging data, we estimated the size of the population in the Combahee was less than 1,000 fish of age-4 or greater. We have wondered if there are ecological constraints to increasing the size of these coastal populations. Thus, we radio-tagged approximately 30 Combahee River striped bass, none of which were smaller than 10 pounds. We hypothesized that many of these fish would die during summer, due to limitations in thermal refugia. This fall, we are still tracking 23 fish, which is good evidence that - during this study year - striped bass had the habitat needed to make it through the summer.

Thank you again for the opportunity of presenting this information, I hope it has been relevant to the Gulf restoration effort.

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**QUESTION (Charles Mesing):** I didn't hear any talk about hydrilla. I am aware of the history of Lake Marion. Have you looked at the impact of hydrilla with respect to successful reproduction of striped bass?

**ANSWER:** In the late 1980s Lake Marion had 30,000 acres covered with hydrilla. From a striped bass point of view, the eggs are coming into a lake which was filled with hydrilla. Since then we've put in lots of triploid grass carp, and there is currently no hydrilla in the system. The largemouth bass fishermen are telling us to put it back in. But from a striped bass point of view recruitment of striped bass has appeared to increase since getting rid of the hydrilla. Our natural reproduction has increased because it freed up the nutrients in the upper part of the lake from growing plants to growing plankton.

## Restoration of Gulf Striped Bass in the Blackwater River

*David M. Yeager, Florida Game and Fresh Water Fish Commission*

ABSTRACT:

Gulf race striped bass were first introduced into the Blackwater River in 1987 to reestablish a striped bass population and to create an additional sport fishery. Cool summertime water temperature was the primary reason this river was chosen for striped bass reintroductions. Over 700,000 fingerlings and 28,000 phase II fish, 7 to 10 inches in length, have been stocked in the system since 1987. Fall electrofishing samples for young-of-the-year fish have indicated good survival of stocked fish each year. An age and growth sample taken in the summer of 1997 showed that about half of age 2 and all of age 3 fish had reached the legal harvest length of 18 inches. Daytime creel surveys from October 1997 through June 1998 did not show significant harvest of, or effort for, striped bass in the Blackwater River. However, anglers participating in a striped bass angler diary program were successful. These anglers were more successful fishing at night or during dawn and dusk. The first broodfish was collected from the Blackwater River in 1995. Since then 70 broodfish have been collected during the last three spawning seasons. Eligible female broodfish have averaged 22 pounds, ranging from 11 to 37 pounds, and five fish over 30 pounds have been collected the past two years. Based on the findings of this study, striped bass have been successfully reestablished in the Blackwater River. Future studies will determine if natural reproduction is occurring in the system.

**QUESTION (Jim Williams):** Do you know what they are feeding on?

**ANSWER:** That is one of the questions that we had originally based on forage space in the system, there is not a whole lot of freshwater forage. They appear to be mainly feeding on mullet and shrimp, since saltwater flows in with the tide from the bay. One angler that I talked to said the preferred bait is finger mullet.

**QUESTION (Jim Bulak):** I was just wondering if telemetry studies have shown how far out into the estuary the fish go.

**ANSWER:** Not very far. I don't think Rick tracked any fish out into the Pensacola Bay system, but they did go into the Blackwater Bay system. Most of the time they were in the lower river, and then in the spring time they spawned and went up the river. There is no cool water from springs, but there are some cool water areas, such as tributaries coming into the main river channel. The fish that Rick tracked went into these cool water areas at times, but they didn't necessarily stay there. They would move in and out of the cool water.

**QUESTION (Jim Williams):** Have you tracked any into the Escambia River?

**ANSWER:** No, we don't see a whole lot of mixing between systems. We have creel surveys also ongoing in the Escambia. We rarely see a striped bass come in on creel in the Escambia. They are mainly confined to the Blackwater and Yellow Rivers.

# Performance Evaluation of Gulf versus Atlantic Striped Bass in Lake Talquin, 1988-1996

*Charles Mesing, Florida Game and Fresh Water Fish Commission*

ABSTRACT:

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Relative survival and growth of Gulf and Atlantic striped bass, *Morone saxatilis*, were investigated using mitochondrial DNA (mtDNA) markers as genetic tags. Equal numbers of Gulf and Atlantic phase I striped bass were co-stocked into Lake Talquin from 1988 to 1993. Three unique mtDNA Gulf genotypes, AB-2, B-2 and C-2 and three Atlantic genotypes, C-1, D-1, and B-1, were represented in five year classes. Relative survival of Gulf and Atlantic striped bass was similar from age 1 to 5 after adjusting for failed air bladder inflation or initial stocking and handling mortality. However, Atlantic striped bass from the 1992 year class demonstrated significantly ($P < 0.001$) higher survival than Gulf striped bass at age 3 ($p < 0.05$) and continued through age 4 ($P < 0.05$). Atlantic striped bass exhibited significantly greater mean total lengths and weights at age 1 for three of the six year classes, although size at stocking may have influenced these results. There was no significant difference ($p > 0.05$) in mean total lengths and weights from age 2 to 5. ANCOVA analysis revealed no differences ($p > 0.05$) in the elevation of the regression lines, indicating similar condition. Because survival and growth between the two races were similar, only native Gulf striped bass should be propagated for stocking restoration efforts along the Gulf of Mexico.

## Ready or Not, Here They Come: The Potential Contribution of the Coosa River Striped Bass to the Lower ACT Basin

*Bill Davin, Department of Biology, Berry College*
*Steve Smith, Alabama Department of Conservation and Natural Resources*

Striped bass are native to the lower Alabama-Coosa-Tallapoosa (ACT) River Basin. Reports dating back to the late 1800s show them being caught as far up the Coosa River as Wetumpka, AL and the Tallapoosa River as Tallasee, AL. Currently, upstream movement of coastal Gulf strain stock is blocked by a series of dams. The Alabama and Coosa Rivers in Alabama have been impounded at ten sites and both major tributaries of the Coosa River have been impounded in Georgia. As a result of the impoundments, and in an effort to increase angling opportunities, striped bass have been stocked in the various impoundments since the mid-1960s. Alabama has stocked in excess of 6 million young-of-the-year (YOY) striped bass in nine of the ACT reservoirs, and all stockings since 1992, involving nearly 2.4 million fish, have utilized Gulf strain striped bass. Georgia has stocked over 5 million YOY striped bass upstream of Weiss Reservoir, AL, between 1972 and 1997. With the exception of the 1993 and 1994 year class, all stockings involved the Atlantic strain. The 1993 and 1994 stockings (152,000 striped bass) consisted of Gulf strain fish released into Allatoona and Carters Lakes in Georgia.

Stocking of Weiss Reservoir was discontinued in 1986, yet biologists and anglers began to report the presence of young striped bass in 1993 and 1994 in the reservoir and upstream in the Coosa River near Rome, GA. Beginning in 1997, a study was undertaken to determine if a reproducing population had been established in the Coosa River and it's tributaries upstream from Weiss Reservoir. During both the 1997 and 1998 spawning seasons (late April through early June) striped bass eggs were collected from the Coosa River and numerous sites along the Oostanaula River in Georgia. One site on the Oostanaula River in Rome, GA, (2 km upstream from where it confluences with the Etowah River to form the Coosa) yielded the highest number of eggs. This site was sampled twice weekly in 1997 and every-other day in 1998 using a stationary ½ meter-750 micron mesh plankton net with a flow meter attached. An attempt was made during each sampling effort to filter 100 $m^3$ of water. Samples were preserved and stained in 7% formalin with Biebrick Scarlet and Eosin B. Eggs were later counted and staged.

Collections at the Oostanaula site yielded 771 and 15,879 eggs in 1997 and 1998, respectively. Egg densities peaked on the 12$^{th}$ of May for both years, with 7.6 eggs/$m^3$ at 19°C collected in 1997 and 77.1 eggs/$m^3$ at 18.5°C in 1998. The average flow rate during the spawning peak of 1997 was 125 $m^3$/sec. Assuming even distribution of eggs within the channel, this translates to 3.4 million eggs per hour. Eggs were only present for twelve days in 1997 (3 samples); therefore, extrapolation of the actual number of eggs contributed to the system is difficult. However, during the 1998 spawning season, eggs were collected over a 30-day period and samples were taken on 15 of those days. In addition to the peak density on May 12, densities of 45 and 41 eggs/$m^3$ were observed on May 14$^{th}$ and 16$^{th}$, respectively. Extrapolation of the collection results indicates that the mean density during the 5-day peak period was 51 eggs/$m^3$ and an average of 9.1 eggs/$m^3$ were present over the entire spawning period. Since sampling was conducted once each sample day, it is unknown exactly how long the observed densities were maintained by spawning activity during each 24 hour period. Therefore, estimates of the potential contribution are based on the observed densities being maintained for 1 and 12 hours for each 24-hour period and multiplied by the USGS reported hourly discharge for the site. The estimated number of striped bass eggs entering the Coosa River range from 73 to 900 million for the 1 and 12 hour periods, respectively. When the observed densities are extrapolated to include non-sampled days, the estimates range from 164 million to 2 billion eggs for the same two density periods. Assuming a 1% survival rate, this could potentially mean as many as 20 million striped bass were added to the system during 1998. This is nearly twice the number of striped bass that have ever been stocked into the ACT Basin.

The Alabama Department of Conservation and Natural Resources undertook a project from 1995-97 to determine food habits, year-class strength, and downstream movement of striped bass from Weiss Reservoir. Fish were collected using gill nets from Weiss, Neely Henry, Logan Martin, and Lay Reservoirs. Otoliths were used for aging and dorsal fIN clips were used for mitochondrial DNA analysis. A total of 85 striped bass representing 5 different year classes were analyzed (approximately 20 per reservoir). While 79% of those fish were Atlantic strain, the most interesting fact is that 50% of them came from the 1993 and 1994 year classes. Again, no Atlantic strain fish were stocked by either state during that two-year period. There was also a decrease in the percentage of Atlantic strain fish present, the farther away from Weiss Reservoir the samples were taken. All the fish sampled in Weiss were determined to be Atlantic strain (N=24), 94% (N=19) were Atlantic strain from Neely Henry, 60% (N=20) in Logan Martin, and 59% (N=22) in Lay Reservoir.

It is evident then, that striped bass are spawning in the Oostanaula River which is a major tributary to the upper ACT River Basin. The 1998 spawning activity potentially could have contributed in excess of 2 billion eggs into the Coosa River and subsequent downstream impoundments. The majority of the fish stocked upstream of Weiss Reservoir were Atlantic strain fish and it appears that these fish and/or their progeny are currently spawning, and the their young are migrating downstream in the ACT River Basin. Any management plan of the Gulf strain striped bass in the lower ACT Basin must take into consideration the potential contribution of the Atlantic strain striped bass in the upper reaches of the Coosa River and it's tributaries.

**QUESTION (Could not identify speaker):** What was used, I guess it would have been Smith's work, to separate Gulfs and Atlantics for the genetic analyses? And, was there any attempt on Smith's part to compare the condition of the Atlantic and Gulf fish?

**ANSWER:** Not that I am aware of. I have a draft of his report, it is a Sport Fish Restoration report, a final report for that state wide program. I don't recall seeing anything looking at condition factors.

**QUESTION (Could not identify speaker):** Did you take lengths and weights?

**ANSWER:** I would assume. Again, I did not want to steal too much of Steve's work. The two projects together really emphasize the fact that they are spawning and they are moving. What the magnitude is, we do not know at this point but it is certainly something to keep in mind.

**QUESTION (Jim Williams):** Where is the fishery for striped bass, right below the dam or in the river proper?

**ANSWER:** The best fish were surveyed when they were behind the dam, but if you talk to anglers the whole way along the river they find fish. There is very limited access using a boat. However, I have heard that a number of people fish a stretch downstream from the dam and catch fish. I don't know anybody angling as far down as the mouth.

**QUESTION (Doug Frugé):** Have you been able to identify any kind of unique characteristics about that stretch of river that is attracting the fish there to spawn?

**ANSWER:** No, I can not. The whole distance we traveled was about 47 miles long. That stretch is all gravel rock, relatively shallow, uniform temperature, uniform DO, we have done a lot of water chemistry there.

**QUESTION (Jim Bulak):** Has there been any genetic characterization of these fish?

**ANSWER:** No, that is one thing I hope to do. The first thing I have to do is find some samples of both to get started.

## Management and Taxonomic Implications of Gulf Striped Bass Molecular Genetics Information

*Ike Wirgin, New York University Medical Center*

There are going to be two objectives in my talk, including 1) is the extant population in the Apalachicola-Chattahoochee-Flint (ACF) River system today genetically distinct from southeastern Atlantic populations and 2) if that is the case, how genetically does the population today in the ACF compare to what it was historically before the introduction of any Atlantic coast fish in the system in the late 1950s and the early 1960s.

Before I start, I would like to acknowledge support that I have received over the years from several different agencies. Without this financial support obviously I couldn't do the work. But in addition to that I really appreciate the confidence that they have had in me and the encouragement that they gave me. I am talking about the Fish and Wildlife Service, originally Glenn McBay and Doug Frugé today; Ron Lukens of the Gulf States Marine Fisheries Commission; and representatives from the three states that entered into cooperative agreements from Georgia, Alabama, and Florida. In particular, I have to acknowledge the support I have had over the years from Charlie Mesing, despite some of the pictures he put up of me this morning.

I am associated with the New York University Medical School, and I am a geneticist. But the reason I got into this is because I like to fish. I feel that it is important that I give you a little bit of a idea in terms of the different molecular genetic gizmos that we have out here today to look for population structure. What you use is genetic tags. These include allozymes, mitochondrial DNA, DNA fingerprinting, and micro-satellites. Allozymes was the original method that was used to locate genetic diversity among populations which could guesstimate genetic diversity of the population. Unfortunately in striped bass I and many other workers found absolutely no allozyme variation among striped bass population, probably due to the fact that allozyme analysis looks at the protein products of genes that are important for survival. If the gene is important for survival, the chances of it evolving quickly are remote. Remember if you are looking for populations structure based on genetics you have to have some variations. With no variation, you are stumped before you start.

Secondly you have to have geographic partitioning of that variation. While allozymes provide us with no variation, another method that came along in the early 1980s was mitochondrial DNA, and there are two ways to look at that. In one way you look at the whole mitochondrial DNA molecule which is a circle of 16,000 base pairs. The other way, which became popular in the late 1980s and early 1990s is to use the polymerase chain reaction (PCR) to amplify a short stretch of mitochondrial DNA, in other words, rather than looking at the whole 16,000 base pairs, PCR looks at from 200 to 1000 base pairs. These would be areas that might have informative polymorphisms for the purpose of separating fish. Mitochondrial DNA is maternally inherited. This provides information about maternal descent only; there is no information about paternal lineage. The nice thing about looking at mitochondrial DNA using PCR is that you can look at very small life stages such as individual eggs, larvae, or a piece of a tissue. Another method that we used on striped bass populations in the ACF and southeast Atlantic is DNA fingerprinting. It is a nuclear DNA based technique, and it reveals a lot more genetic variation than mitochondrial DNA. Information is revealed about both paternal and maternal lineage, but the interpretation of gels, the output, is rather complex. The final method that people are using is micro-satellites. Micro-satellites reveal the highest level of genetic variability of any of these methods. Once again it is a nuclear DNA based technique so you are looking at both paternal and maternal descent, and once again we can look at tiny little pieces of tissues. It is rather simple to interpret the results from micro-satellite gels, because in this case you are looking at a single genetic locus.

When I first got involved in this study I was informed that, historically, striped bass from the Apalachicola River system and from the Alabama and Talapoosa River systems had lateral line scale counts that were significantly higher than striped bass of any Atlantic coast population. Those studies along the Gulf were done by Barkuloo and Brown. In fact, if you compared lateral line scale counts in Apalachicola fish and Alabama fish to those in the St. Johns River there were no overlaps. During the 1960s to 1970s it was found that lateral line scale counts had eroded in the striped bass in the ACF basin, and, therefore, it was not as reliable a means to discriminate between Atlantic and Gulf coast fish. In addition, and most importantly, it suggested that there may have been significant introgression of Atlantic coast genes into the ACF population due to the historical stocking that occurred from Santee Cooper River fish in the 1960s and 1970s. Based on these issues, we got into striped bass genetics work in about 1981, and the question was, is the ACF population still genetically distinct from Atlantic coast fish.

*[Dr. Wirgin showed a series of slides depicting gels from Gulf and Atlantic fish that he has analyzed. This was done to demonstrate to the audience the different techniques and the different outputs.]*

In total, over 15-16 years, we have analyzed 741 fish from the ACF system. So all brood fish were characterized in terms of mitochondrial DNA genotype. In subsequent years they were analyzed also in terms of nuclear DNA genotypes. We learned that if we lump the A2s, B2s, C2s, and a couple of early D2s, we find that about 55% of all the fish analyzed from the ACF showed this 2 genotype.

We also looked at fish from throughout the Atlantic Coast from the Tapazentac and the Merrimesu Rivers in New Brunswick and Nova Scotia, the Scubenacity and the St. Johns in New Brunswick and all the way down the Atlantic coast. We even looked at striped bass in San Francisco Bay, which were transplanted there about 110 years ago. And then we looked at fish from Oregon. The result is that not a single fish out of thousands that we analyzed showed this XBA2 genotype. This led to a confidence that this genotype is a good marker of fish of original Gulf coast descent. In addition, analysis of samples from Gulf systems other than the ACF indicates a distinct lack of the XBA2 genotype. Interestingly, if we compare the frequencies of the As, Bs, Cs, and Ds in this composite Gulf sample to Santee-Cooper fish that I collected in 1992, you can see that about 78% of all Gulfs showed a C genotype and about 20% showed a D genotype, and that is comparable to what we saw in these 49 Santee-Cooper fish that we collected in 1992, which suggests that all these fish that we looked at back over these years were of Santee-Cooper Reservoir descent.

It is also interesting to note that we found no difference among all those river systems along the Gulf in terms of length genotypes. However, if we use the same technology and look at striped bass in the Roanoke River in North Carolina, the Santee-Cooper system, and fish from the Ogeechee River, we see significant differences among all three of these systems, with highly significant differences just using a single marker alone. So once again that provides pretty strong evidence that the lack of genetic differentiation among Gulf coast rivers using the same marker in comparison to the high levels of genetic differentiation along the southeast Atlantic suggests that all those fish in other Gulf coast rivers probably were or descended from Santee-Cooper stocked fish.

Remember mitochondrial DNA is strictly maternally inherited, so we wanted to also see if we could find similar differences between ACF fish and Atlantic coast striped bass using nuclear DNA analysis. In 1991 or 92 we used a DNA fingerprinting technology and constructed gels. It was very clear that a high percentage of ACF fish showed DNA fragments that were absent in all Atlantic fish. For instance, using this DNA fingerprinting 93% of ACF fish revealed a genotype that was absent in 51 Atlantic fish. Similarly with this other DNA fragment, 90% of ACF fish showed something that was absent in all Atlantic fish. This is strong genetic differentiation using the nuclear DNA markers. We also developed some nuclear DNA probes which enabled us to look at single copy stretches of DNA. DNA is divided into basically two different classes, you have got single copy nuclear DNA, the type of DNA you find in genes, and then between the genes you have got a lot of repeats. The repeats show a lot of DNA diversity. The single copy genes show less diversity, but even in that case we found high levels of genetic diversity at three single copy nuclear DNA locus sites in ACF and southeast Atlantic coast striped bass. For instance, in one single copy locus we saw that 60% of ACF fish showed us a genotype that was only in 2% of Atlantic fish. Similarly, 98% of Atlantic fish show us a genotype that is only in 29% of Gulf fish. So this is another type of nuclear DNA analysis that once again showed us the same thing that we saw with mitochondrial DNA, i.e. strong differences between ACF and Atlantic coast fish. We even went a bit further and developed micro-satellites for looking at striped bass nuclear DNA. What are micro-satellites? Micro-satellites are little short stretches of tandem repeats. For instance, a particular micro-satellite locus that we call striped bass 127, there are at least 16 copies of ACs, so you have AC, AC, AC repeated 16 times. The variability here occurs when among individual fish when you have 16 copies of one fish, another fish may have 18 copies of this, another fish may have 20 copies of this. So we developed the ability to analyze about 10 or 12 micro-satellite loci in striped bass.

When we look at all the micro-satellites that we could use in striped bass, some have low levels of variability and some have high levels of variability. We compared micro-satellite diversity in striped bass of the ACF versus Atlantic coast striped bass. The results of genotype frequencies in certain micro-satellite loci used revealed markings in 60% of ACF fish that are absent in all Atlantic fish. So here is another type of nuclear DNA analysis, another type of DNA that shows strong differentiation between ACF and Atlantic coast fish.

Now we know that based on maternally inherited mitochondrial DNA, and based on both paternally and maternally inherited nuclear DNA, and using four different types of analyses that the current population in the ACF is genetically very different from all Atlantic coast populations. The next question was, how different or how similar is the current population in the ACF to what it was historically, prior to the introduction of any Atlantic coast fish in the system. We were able to obtain exactly 78 striped bass from two museum collections, one at Tulane University and the other at Cornell University. These fish were all collected from the ACF prior to the introduction of any Atlantic coast fish in the system. So these were pure Gulf strain striped bass. The problem was they were in formalin. If you are doing DNA analyses, formalin is the worst preservative that you could possibly use. If you ever want to save some samples, you don't have the money for analysis, but you want to put them away, preserve them in alcohol and they stay useful forever. Never put them in formalin. Since these samples were in formalin, we had to go through all kinds of procedures to be able to analyze them. We compared the frequency of the XBA1 and 2 genotype in these archived museum samples compared to what is in the ACF population through our 1997 collection. What we found was that 50% of the archived fish showed the 2 genotype and exactly 50% of the archived fish showed the 1 genotype. We were successfully able to analyze 52 of the 78 fish. When we compared these frequencies to what is in the extant ACF population we don't see a significance difference. Also note that not all of the archived fish were 2s, half of them were 1s. Everyone was saying initially that if it is not a 2, it is not a Gulf. Well, that's not true. So, we concluded that there is no significant difference in mtDNA genotype frequency between archived and extant ACF samples. This suggested that there had been no significant introgression of Atlantic mitochondrial DNA genotypes into the ACF gene pool. Remember though, mitochondrial DNA is strictly maternally inherited, well it is close to strictly maternally inherited. So we are right now trying to do the same type of analysis on these archived samples looking at that micro-satellite polymorphism that I showed you before.

The results of these ACF studies in total show us that the extant striped bass population in the ACF is genetically diverse from all Gulf coast populations based both on mitochondrial and four different types of nuclear DNA analyses. The ACF is probably the only river to host remnants of a Gulf strain of striped bass and there has been very little introgression of paternally derived Atlantic coast mitochondrial DNA in the ACF population. This then leads me to this question, what would we find if we look at other important anadromous species along both the Gulf and Atlantic coast, for instance American shad, Alabama shad, and Gulf sturgeon, all designated as subspecies. Striped bass from the Gulf has not been designated as a subspecies. What criteria are normally used for the designation of subspecies status? Distribution, and we certainly have that in the case of striped bass. Life history variation, which might be evidenced in terms of coastal migrants versus non coastal migrants. Morphology, and before Atlantic coast fish were introduced into the system, there was almost no overlap in terms of lateral line scale counts. Now we have real strong genetic differentiation between the two forms. Should Gulf striped bass be considered a subspecies?

Another part of our work that Charlie mentioned and others speakers also this morning was the potential to use genetic tags in terms of various performance evaluation tests. What are some of the advantages of these genetic tags? Well, obviously, there is long term retention, even multi-generational. You don't lose your tag, there is no expense in tagging and all the fish that you rear are tagged for you. Another advantage is every single recapture provides information for you. No handling stress in tagging, and you can even get information on individual eggs and larvae. Obviously, the disadvantage is the cost at the other end in terms of analyzing the samples. And the cost at the beginning in terms of finding polymorphisms that will be useful to you in terms of your project.

Here are some potential uses of these genetic tags. These include evaluating the optimal size for stocking of fish, optimizing sites for stocking in a system, evaluating performance, potentially distinguishing between natural and hatchery produced fish if you take a rare genotype for your hatchery production, following the movements of cohorts within a system, and distinguishing between striped bass and their hybrids.

What are some of these types of tags? Well so far we just used mitochondrial DNA, and if we just consider base substitution down in here in the Gulf, you basically have four genotypes you can use.

If you use length variance you have As, Bs, Cs, and Ds. So, if you just consider these two categories together, you have 16 potential genotypes you can use. Using micro-satellites, the potential is unlimited. From the single copy nuclear DNA, a marker that I described, so far there are six different genotypes you can use. So you can see that the potential to use genetic markers for field and hatchery studies is great.

Thank you for the opportunity to participate in this workshop. I'll be glad to answer questions.

**QUESTION (Chuck Coutant):** You may have said and I missed it, but you have the ACF clearly distinguished from both Atlantic and other Gulf. Does it break down or have you gotten to the point of saying each river system among the Gulf stocks is distinct?

**ANSWER:** No, I say exactly the opposite. All other Gulf systems are all identical and suggests to me that they are all remnants or descendants of stocking from the Santee-Cooper.

**QUESTION (Paul Mauck):** Of course in Lake Texoma we have a combination of fish, including fish from the Chesapeake Bay and the Santee-Cooper Reservoir. Now some people believe that we have inbreeding, causing reduction in growth. We haven't come up with the funds to answer that question, but that is something that we are interested in resolving.

**ANSWER:** Yes, Bruce has talked to me about that. I think the possibility is there to do a real good study.

**QUESTION (Jim Williams):** Did you have anything from the St. Johns?

**ANSWER:** Yes, a couple of fish. I think I got about 8 or 10 from the ACF back in 1983 and 6 from the St. Johns. The St. Johns fish also showed the 1 genotype. The reason we stayed away from the St. Johns was because there had been so much stocking of unknown origin in that system.

**QUESTION (Jim Bulak):** Did you say that stocking changed the scale counts.

**ANSWER:** I don't know if that is the case. I said that after the stocking the scale counts diminished. Now, you could make the argument that that was due to the stocking or you could make the argument that there is a lot of inherent variation in lateral line scale counts in fish.

**QUESTION (Columbus Brown):** Ike, have you looked at any of the historic samples from any other of the basins in the Gulf?

**ANSWER:** No. Do any other archives exist?

**RON LUKENS:** You have looked at everything that we know of from the Gulf of Mexico.

**ANSWER:** Somebody told me a couple of days ago or today that there were some fish perhaps some place else that I had missed.

**RON LUKENS:** Well speak up and let's find them. We underwent two processes. Jim Barkuloo conducted a search to try to find every archived fish that was available, and then we went back again when we started working with Ike through the Commission and redid that effort. We didn't come up with any new sources, so if anybody knows of any we would be happy to hear about it.

**Comment:** Scales are good to analyze too, that is probably easier than the fish is. If anyone has any scales from fish collected before stocking Atlantic coast fish, those could be used.

**QUESTION (Doug Frugé):** Are we only looking for ACF fish though, or are we looking for fish from any system?

**ANSWER (Ron Lukens):** We were looking for fish caught in Gulf of Mexico river drainages prior to the 1950s and 1960s.

**QUESTION (Mike VanDenAvyle):** My question further relates to your confidence in the statement of a lack of introgression in the ACF. I am not familiar enough with the technique to understand whether results from one marker are sufficient to make that broader conclusion.

**ANSWER:** What I think I said was that based on mitochondrial DNA ,which is maternally inherited, there was no evidence of significant introgression in the system. It is possible that there could be paternally mediated introgression in the system that we did not look for but which we are looking for today.

**QUESTION (Mike VanDenAvyle):** I don't have any angles here, I am just trying to understand from one of the experts that work on this kind of thing, whether that level of information is really conclusive.

**ANSWER:** Well, the only thing I can say is there is not a hint in terms of looking at the frequencies of the informative genotypes in current populations, from which we have a tremendous sample size and the old population, for which we have samples from 50 fish. Just based on that there is no significance genetic difference at that one site between what we see in the population today and what existed prior to the introduction of Atlantic fish.

**QUESTION (Ron Lukens):** Is that information on that one site sufficient to make that conclusion?

**ANSWER:** In terms of maternal transmission of informative genotypes, I'd say yes.

**QUESTION (Charlie Mesing):** I would suggest that based on tremendous potential for reproduction, we would be seeing a shift from the 2 genotype to the 1 genotype given the capability and the number of eggs they could produce.

**ANSWER:** Yes, but we started in 1983. We missed when that shift would have occurred.

## Gulf Striped Bass Taxonomy

*Jim Williams, Biological Resources Division, US Geological Survey*

***This is a transcript of Dr. Williams' remarks recorded during the workshop.***

First of all, I am really pleased to be here today. I want to start out with my first exposure to striped bass. This is a picture of a dam at Tallasee, Alabama, on the Talapoosa River. I grew up in east Alabama, a small town near Talladega. I had an uncle that fished below the dam near Tallasee and below the dam on the Coosa River. The highlight of his year was catching huge stripers. I remember being a first or second grader and seeing some striped bass almost as big as I was. He said they get up to six feet long and they eat kids sometimes. At that point I thought I was never going swimming in the Coosa and Tallapoosa River again as long as I lived. People are now talking about restoration of striped bass in those areas. These dams are two clear impediments of concern if biodiversity or restoration efforts are of interest. You only have to look at impoundments in the southeast when the striped bass populations started going down. They are correlated. Channel modifications constitute another problem, primarily related to temperature. The channelization projects where streams are straightened and the canopy is removed, the water heats up and you lose thermal refugia. Another issue that must be considered if restoration is needed is the amount and frequency of non-native fish introduced per state. The numbers are tremendous. Eventually this is going to catch up with us, if it hasn't already in some places.

The question posed for my presentation is whether or not striped bass in Gulf basins is a subspecies or evolutionary significant unit. This is a taxonomic issue that has received very little to no attention. That lack of attention is surprising, but I think in part it has been because of the lack of exposure of ichthyologists to materials from the Gulf basin. They are not the sort of fish that ordinarily turn up in a fish collection using standard collection methodologies. There are reportedly some specimens at the University of Alabama, some in Florida, and a few at Auburn University. I have got the word out to try to locate additional specimens of striped bass collected in Gulf drainages prior to known stocking efforts.

What is significant about striped bass in the Gulf basin. If you look at the Atlantic coast, there are coastal drainages that flow into either the Blue Ridge area or for the most part drain directly into the Atlantic. In the Gulf of Mexico basin the headwaters are for the most part above the junction of the coastal plain and the Piedmont, with the exception of the rivers in west Florida. Yesterday we discussed some of the unique characters of striper populations around the southeast. The geologic history of the area is important to understanding the population characteristics. Prior to glaciation in the southeast some 20,000 years ago, Florida was roughly twice the size it is today. If some of the small rivers in Florida are extended to account for that pre-glaciation situation, there were some major drainages. Due to glaciation, those large systems have been truncated. The ACF system was much bigger prior to glaciation, and probably joined with the Ochlocknee River. There is some evidence of fossil freshwater mussels, for example, from the Tampa Bay area and from the Suwannee basin that are now endemic to the Apalachicola and Ochlocknee Rivers. These situations help us understand the distribution of species and the possible effects of their separation in geologic time.

If you look at Florida, the topography is rather low. In fact it has been proposed that the Suwannee River might have formed a channel across the state. This is a highly debated, but plausible, issue. Whether such a channel would have been favorable for the movement of striped bass is another question.

If you assume a roughly 60 foot flood, it is easy to see that some areas would have flooded across the state. In fact such a flood would have wiped out most of the Yellow and the Blackwater, leaving them as minor tributaries.

The number of species of fish per basin will generally indicate the level of diversity. How does this manifest itself in terms of marine systems? There are known subspecific differentiations between Gulf and Atlantic populations of marine fish. If the St. Johns River is assessed, there will be a certain subspecies. Moving around to the Gulf, there will be a different subspecies to the one found on the Atlantic. Something is intervening between the Gulf and Atlantic subspecies. This is not an uncommon pattern. There are a lot of species that are found from the Mississippi River west or the Mississippi River east, and then some go all the way across. What does this mean geologically, and how does it relate to species separation?

Dr. Wirgin and others have discussed the situation regarding striped bass. Let's look at some other examples. There seems to be a similar situation with American shad and Alabama shad. They are similar in size and appearance, and viewed together one would find it difficult to separate them without collecting some meristics data. It is the same with striped bass. Another example is Atlantic sturgeon versus Gulf sturgeon. Again you can't really tell them apart just from a cursory look. They can only be separated by looking at meristic characteristics. These are recognized as different subspecies.

Looking at the distribution on the Gulf coast of native striped bass, there are so few individuals left that it is difficult to make hard taxonomic decisions. Such decisions are very sensitive issue and should not be taken lightly. There appears to be ample material to make some decisions from the Apalachicola basin and perhaps from the Mobile Bay drainage based on historic samples. However, smaller drainages to the west of the Mobile basin have so little material available it is difficult to say exactly how this all fits together. At some point some assumptions will have to be made based on the amount of material that is available from the Alabama and Apalachicola systems.

The origin of any particular species is controlled by time, space, the ecology, and biology of the organism. It is clear that we have had geographic separation of the Gulf population from the Atlantic populations. In addition, we are dealing with systems in the Gulf that ecologically are different than a lot of the Atlantic coast. These factors lend credence to having a distinct species of striped bass in the Gulf coast. Species represents the fundamental unit of natural science. There are currently about 22 species concepts recognized. I will mention a few of them to give you an idea of where the Gulf coast population of striped bass fits. The morphological species concept says that the species is the smallest group that is consistently distinct and distinguishable by ordinary means. This concept initially did not include consideration of mitochondrial and nuclear DNA, but relied on ordinary means of the day. At this point in time, genetic evidence could fit this concept.

The biological species concept, the one that most people in this room probably have grown up with, is genetically distinct and reproductively isolated populations. How do Gulf basin striped bass fit into this concept. They are certainly reproductively isolated and so do not likely interbreed with Atlantic individuals.

The evolutionary species concept is basically a lineage based concept in populations that are evolving separately from others with its own evolutionary role and dependancies. Different lateral line scale counts would seem to support this concept.

The genetic species concept relies on the smallest detectable sample of self-perpetuating organisms that have unique sets of characters. That concept seems to fit Gulf basin striped bass population.

Regarding determining whether or not striped bass in the Gulf drainages is a distinct subspecies, we must determine how much stocking of Atlantic stock occurred in the Gulf basin. That will determine in part how far the issue can be pursued. The amount of genetic material available from the Alabama and Apalachicola systems makes a good case for subspecies designation. It also should be determined how much influence the Atlantic genes may have had on the appearance of striped bass in the Alabama and Apalachicola Rivers. What impact are the Atlantic striped bass in the Coosa River, working their way down the system into the Alabama River, going to have on the Gulf genetic stock occurring there? Meristic and morphometic data could easily be collected to define very precisely the Gulf basin populations.

Regarding restoration, in closing, the use of hatchery fish to supplement and reestablish stocks is often discussed. This is one useful approach, but habitat quality and quantity must also be evaluated. Will the use of hatchery-reared fish for stocking simply create a put and take fishery in the absence of habitat restoration? This question applies to all species of fish, but anadromous species are particularly representative, because of the range of habitat and environmental requirements in their life histories. Dams and channelization are two of the most significant contributors to habitat decline for anadromous species, and represent two of the most important impediments to restoration. We can stock fish every year, but until spawning and migratory habitats are restored, and until sufficient thermal refugia are available, restoration is unlikely.

There were no questions for Dr. Williams.

## Overview of Fisheries Stewardship Initiative

*Doug Frugé, U.S. Fish and Wildlife Service*

The final six presentations provide information on currently ongoing projects being funded through the Fish and Wildlife Service's Fisheries Stewardship Initiative. I would like to take a few minutes to introduce these presentations by telling you a little about the Fisheries Stewardship Initiative, and a little background on these projects.

### Fisheries Stewardship Initiative

The Fisheries Stewardship Initiative is a line item in the Fish and Wildlife Service's budget. Funding began in Fiscal Year 1994.

The initiative was conceived as a way to fund special projects aimed at conserving fishery resources, restoring habitat, preserving genetic diversity, evaluating hatchery stocking, or protecting the health of wild fish stocks.

Funds are allocated to FWS organizations based on competitive proposals. Proposals are developed by FWS offices and submitted by the regions to the Washington office, where they are evaluated by a panel composed of FWS fisheries personnel.

### Restoration of Striped Bass in Three Gulf of Mexico River Systems

In 1996 the FWS Fisheries Resource Office in Panama City, Florida and I jointly developed a proposal focused on Gulf striped bass restoration in three key anadromous river systems: the Apalachicola-Chattahoochee-Flint (ACF) system, the Pascagoula River in Mississippi, and the Lake Pontchartrain drainages, primarily the Pearl and Tchefuncte rivers in Louisiana. The proposal was funded for a three-year period beginning in Fiscal Year 1997.

The project is being implemented through a multi-agency partnership, with state agencies and university research organizations conducting component parts of the overall project. The GSMFC is playing a key role in directly administering subcontracts with five of the six partner organizations, with funds being provided to the GSMFC through a cooperative agreement. An intra-agency agreement with the Biological Resources Division of the US Geological Survey provides funding to another project participant.

### Project Participants

Participants in the projects include the Florida Game and Fresh Water Fish Commission (now the Florida Fish and Wildlife Conservation Commission) and Georgia Department of Natural Resources in the Apalachicola-Chattahoochee-Flint system. The Georgia DNR portion is being carried out by the Georgia Cooperative Fish and Wildlife Research Unit.

In the Pascagoula River, projects are being carried out by the Gulf Coast Research Laboratory and Mississippi State University.

The Lake Pontchartrain rivers projects are being implemented by the Louisiana Department of Wildlife and Fisheries and the Louisiana Cooperative Fish and Wildlife Research Unit.

As of this workshop, all projects have completed at least one year of field work, though they are all still on-going, so results are all preliminary at this time. Even though FY 1999 is the last year of funding, completion of all the projects won't occur until mid 2000 since most of the projects did not begin until mid 1998. At this time I'm going to turn the program back over to Columbus to introduce the first of the Fisheries Stewardship Initiative presentations.

## Gulf Striped Bass Restoration in the Apalachicola River

*Rick Long, Florida Game and Fresh Water Fish Commission*



**ABSTRACT:** Ninety-nine adult striped bass *Morone saxatilis* broodfish were collected by electrofishing below Jim Woodruff Lock and Dam (JWLD) during the spring of 1998. Forty-nine fish were distributed to federal and state hatcheries. Young-of-year (YOY) sampling in fall 1997 indicated striped bass natural reproduction in the Apalachicola-Chattahoochee-Flint river system increased three-fold following 12 years of stock enhancement; however, YOY relative abundance was still considerably less than that of successfully stocked year classes of 500,000 phase I fingerlings. An estimated angler catch of 364 striped bass during a springtime 14-week creel survey in the tailrace of JWLD was less than half of the 1997 estimate, and was one of the lowest estimates since 1985. Telemetry of 19 age-2 and -3 striped bass, surgically implanted with radio and ultrasonic transmitters, failed to reveal the presence of cold water thermal refugia in the lower Apalachicola River or Intracoastal Waterway (ICW). Four of nine fish traversed Lake Wimico and the ICW to the Apalachicola River, then moved approximately 200 km upstream to refugia in the upper river. A total of only 29 striped bass were collected in cool water refugia in the Chipola River by electrofishing during July and August 1997.


### Introduction

Striped bass *Morone saxatilis* populations native to the Apalachicola-Chattahoochee-Flint (ACF) River system and other Gulf of Mexico river drainages declined following the construction of dams which impeded seasonal migrations to spawning areas and summer thermal refugia (Wooley and Crateau 1983). Cooperative efforts to restore native Gulf striped bass to the ACF were initiated by a Memorandum of Agreement among Florida, Georgia, Alabama, and the USFWS in 1987. Stocking efforts concentrated on Lake Seminole from 1986 to 1990. Phase I and phase II fingerling releases occurred in the lower Apalachicola River and Bay (ARB) following the removal of Dead Lake Dam in 1988, which reopened approximately 100 km of thermal refuge in the upper Chipola River (Hill et al. 1994). Insufficient numbers and poor initial survival of fish stocking into the ARB resulted in failure to determine the full potential for striped bass restoration in the Apalachicola River (Long and Rousseau 1996).

All Gulf states use hatchery reared native striped bass originating from ACF broodstock for restoration efforts and reestablishing fisheries along the Gulf of Mexico. Presently, insufficient numbers of broodfish and hatchery reared fish are available to meet all requests for native Gulf striped bass reintroductions into selected Gulf Coast rivers. There is a need to preserve the uniqueness of the Gulf striped bass gene pool, increase the numbers of adult broodfish available to hatcheries, identify and characterize critical thermal habitat in the ARB, and provide anglers with a unique trophy freshwater fishing opportunity.

### Purpose

The objectives of this study are to determine the size and numbers of hatchery reared striped bass necessary to re-establish and maintain an adult population of native Gulf striped bass at a level which will provide adequate broodfish for a Gulf-wide restoration program and a trophy freshwater sport fishery, and to identify and characterize critical thermal refugia in the Apalachicola River system.

**Methods and Materials**

Striped bass broodfish were electrofished below Jim Woodruff Lock and Dam (JWLD) during March and April 1998. Egg stages for females were determined on site, and suitable females and males were distributed to cooperating federal and state hatcheries.

Phase II striped bass fingerlings were released into the lower Apalachicola River (LAR) and Intracoastal Waterway (ICW) between 1997 and January 1998. Samples of 10 or 15 fish were held in cages, on site, to estimate short term mortality of stocked fish. Attempts were made to hold three replicates from each hatchery truck delivery for 72 hours. However, man-power, time, and holding-space often dictated a shorter or longer assessment period. Only 72-hour data were used to estimate survival for this report. Stocking numbers were adjusted on a daily basis for deliveries with 72-hour data. Total stocking numbers were adjusted based on a mean percent survival for the 72-hour tests.

During May and June 1998, phase I striped bass fingerlings were stocked into Lake Seminole. For each hatchery truck delivery, a minimum sample of 25 fish was held in an aquarium, in receiving water, for a minimum of 72 hours to estimate short term mortality. Survival was assumed to be 100% for deliveries where samples were not to be taken.

During October 1997, 40 standardized nighttime electrofishing samples, two at each of 20 locations in Lake Seminole and the Apalachicola River, were taken to determine relative abundance of naturally reproduced striped bass spawned the previous spring in the ACF River system. Four sample locations were located in Lake Seminole and four each in the upper, middle, and lower Apalachicola River. Samples generally consisted of ten minutes of electrofishing time, although some samples were discontinued after five minutes if excessive numbers of YOY were present. Mean electrofishing catch per unit effort (minutes) values were calculated as a measurement of relative abundance. All YOY striped bass collected were weighed, measured for total length, and fIN-clipped to obtain specimens for mtDNA genetic analysis.

Three monofilament experimental gill nets, 50 m in length and 2.5 m in depth, with three panels each of 25 mm, 32 mm, and 38 mm bar mesh, were set at standardized locations in Lake Seminole during November 1997 and May 1998, for three consecutive nights, to evaluate relative growth of YOY and age-1 striped bass. All appropriate aged striped bass netted were weighed and measured for total length, and if fresh, fIN-clipped for genetic analysis.

A standardized roving creel survey, using non-uniform probability, was conducted on the upper Apalachicola River in the tailrace of JWLD during a 14-week period from February through May 1998. Anglers were surveyed for three hours, five times every two weeks and field data were statistically expanded to provide estimates of striped bass total catch, effort (hours), and angler success (striped bass catch per hour) for the 14-week survey period.

In April 1998, striped bass surgically implanted with temperature sensitive radio or ultrasonic transmitters were released into the LAR and ICW and telemetered to identify and locate cool water thermal refugia. Attempts were made to locate fish a minimum of five times every two weeks.

During periods of good water clarity from July to September 1997, SCUBA diving surveys were made on the Chipola River to verify suspected thermal refugia and to document trends in the number and size of striped bass occupying thermal habitat. Surveys consisted of 15 minutes of bottom time, during which numbers of fish were recorded and sizes estimated. Also, during the period from July to August, the upper 100 km of the Chipola River were electrofished to corroborate trends in striped bass utilization.

## Results and Discussion

### *Broodfish Collections*

A total of 99 adult (≥ 1.4 kg) striped bass ranging in size from 1.4 to 20.2 kg were collected from the Apalachicola River tailrace below JWLD between 23 March and 21 April 1998 (Table 1). Forty-nine fish, 18 females and 31 males, were distributed to Welaka National Fish Hatchery and Blackwater Fisheries Research and Development Center for artificial propagation of progeny. Broodfish were separated into three size classes; >1.4 kg, >4.5 kg, and >9.1 kg, to provide indices for restoration evaluation. Mean catch rates for broodfish >1.4 kg and >9.1 kg size classes, 11.9 (SE = 3.8) and 1.8 (SE = 0.5) fish per hour, respectively, were the highest values recorded from 1990 to 1998 (Long 1997). The catch rate for fish >4.5 kg (6.0 fish per hour, SE = 1.8) was the second highest for this size class.

### *Stocking Evaluation*

During September and October 1997, 98 YOY striped bass were electrofished from Lake Seminole and the Apalachicola River. The fish ranged in size from 111 to 216 mm total length ($\overline{X}$ = 159 mm, SE = 2.5). Of these, 80 YOY were analyzed for mtDNA genotypes (Table 2). More than 90% of the fish analyzed exhibited genotypes not observed among the maternal parents of striped bass fingerlings stocked upstream into lakes Blackshear [A(b)2] and Bartlett's Ferry [C(B)2]. All seven fish analyzed from Lake Blackshear exhibited the A(B)2 mtDNA genotype of the phase I fish stocked in 1997. The results document continued successful natural reproduction of Gulf striped bass in the ACF system. No mtDNA genotypes were found among YOY sampled below JWLD that were not present above the dam. These results suggest that YOY collected downstream were spawned in the Flint or Chattahoochee rivers and released through JWLD.

During October 1997, 58 YOY striped bass were electrofished at a mean catch rate of 0.26 fish per minute (f/m) in combined Lake Seminole and Apalachicola River samples (N = 16). This rate was nearly three times greater than in 1985 (0.09 f/m), when natural reproduction was last evaluated in the ACF. The majority of YOY fish were sampled in Lake Seminole, at a mean catch rate of 0.66 f/m. Mean catch rates declined downstream: 0.31, 0.05, and 0.01 f/m in the upper, middle, and lower Apalachicola River, respectively. The low catch rates in the middle and lower river further demonstrate that natural reproduction likely occurred above JWLD.

During May and June 1998, 533,000 phase I striped bass fingerlings were released into Lake Seminole (including the Flint River). Seventy-two hour survival estimates for phase I striped bass held in aquaria ranged from 0% to 100% for the hatchery deliveries released into Lake Seminole (Table 3). Survival was excellent (98 to 100 percent) for three of four 72-hour tests conducted. The 100% mortality of fish stocked on 29 May 1998 occurred within 24 hours. All fish stocked into Lake Seminole and the Flint River were progeny of females exhibiting the *Xba-2* mtDNA genotype, providing a genetic mark separating these fish from fingerlings released into upstream reservoirs.

Young of the year striped bass were not collected by gill netting in Lake Seminole during fall 1997, suggesting that growth was too slow for age-0 fish to be sampled by this gear type. Six age-1 striped bass, ranging in size from 202 mm to 253 mm were collected by gill netting during spring 1998. None of the fish sampled were fresh enough for mtDNA analysis to determine if they were naturally reproduced or stocked into upstream reservoirs.

Between October 1997 and February 1998, 131,357 phase II striped bass fingerlings were released into the LAR and ICW: 112,457 at White City (ICW) and 18,900 at NM 5.0 on the LAR (Table 4). The mean 72-hour survival of phase II fish held in cages was estimated at 76%, resulting in an adjusted stocking number of 100,065. Phase II fish released at White City exhibited the *Xba-1* mtDNA genotype, while the *Xba-2* genotype were stocked into the LAR. Genetic tags will provide a long term mark for distinguishing the stocking location of 1997 year class fish and/or separation from the majority of naturally reproduced fish from the 1997 year class.

### *Creel Surveys*

During the 14-week peak season creel survey conducted on the tailrace below JWLD, 795 anglers were interviewed, including 108 fishers who expended an estimated 1593 (SE = 380) hours pursuing striped bass (Table 5). An estimated 364 (SE = 74) striped bass were caught and 297 (SE = 49) harvested at angling success rates of 0.19 (SE = 0.09) and 0.15 (SE = 0.07) fish per hour, respectively. All estimates indicated a decline from previous years and were among the lowest recorded since 1985 (Long 1997).

In contrast, an estimated 1,989 (SE = 393) *Morone* hybrids were harvested during 4,396 (SE = 798) hours of effort at a catch rate of 0.50 (SE = 0.23) fish per hour; all similar to estimates from spring 1997 (Long 1997). Sunfish harvest and effort were up 36% and 71%, respectively, compared with 1997.

### *Critical Habitat Surveys*

During July and August 1997, 67 km of the upper Chipola River channel were sampled for striped bass during 14.1 hours of electrofishing effort. An additional 0.7 hours of effort were expended electrofishing individual refugia. A total of 29 striped bass, ranging in size from 305 to 1010 mm total length were collected at a catch rate of 2.0 fish per hour. Only three fish were collected outside the influence of known refugia, two of which were taken in the vicinity of a suspected refuge. This refuge was subsequently identified and located during underwater SCUBA surveys.

During September 1997, six 15-minute underwater surveys utilizing SCUBA were conducted in thermal refugia on the Chipola River. Nine subadult (<1.4 kg) and one adult striped bass were visually observed. In addition, one new thermal refuge, designated Burch Spring, was located and identified. Because of lack of water clarity, underwater surveys were discontinued.

Ten striped bass, ranging in size from 1.1 to 2.5 kg (ages -2 and -3) were collected below JWLD and surgically implanted with temperature-sensitive radio transmitters (Table 6). The fish were held at Joe Budd Wildlife Management Area for five days following surgery to insure successful recovery and then transported to the LAR and released. On 27 April, five fish were released at Old Woman Bluff (NM 5.0) and five at Gardner Landing on East River, a distributary of the Apalachicola River, approximately 13.6 km upstream of East Bay. The fish released at Old Woman Bluff remained at the stocking location for eight days and dispersed. Only one fish (#750), located at NM 0.0, is currently accounted for and is presumed dead. The fish released at Gardner Landing dispersed immediately. Three of the five fish were located in the LAR during the first week. To date, nine of ten radio tagged fish are missing. Attempts to locate the nine missing fish via boat or aircraft (two flights) have been unsuccessful.

On 27 and 28 April, nine fish were electrofished from the ICW, eight from the Gulf County Canal (GCC) and one from Searcy Creek, surgically implanted with ultrasonic transmitters, and released (Table 6). The fish ranged in size from 1.0 to 2.7 kg (ages -2 and -3). Four of the larger fish (1.6 to 2.7 kg) subsequently moved approximately 200 km to thermal refugia in the upper Apalachicola River. One of these sonic tagged striped bass was taken by an angler at JWLD, while the other three have moved among three cool water refugia in the upper river area. Three fish remained in GCC, one of which is presumed dead. Although locations of the two other fish are currently unknown, we suspect they may have also been harvested by fishermen.

**Conclusions and Recommendations**

Broodfish numbers and catch rates indicate a continuing increasing trend of adult striped bass in the Apalachicola River. Extremely high water discharge through JWLD during the fall of 1997 and winter of 1998 probably accounts for some of the increase. Catch rate trend data need to be compared with broodfish data collected by Georgia DNR biologists to better distinguish the effects of high water and increased population size on catch rate values in the Apalachicola River.

Young of the year relative abundance indices indicated that natural striped bass reproduction within the ACF system increased three-fold following twelve years of stock enhancement. Water flow and temperature in known spawning areas were similar to 1985, the last time natural reproduction was evaluated, negating those variables as causes of increased reproductive success. However, YOY catch rates demonstrate that natural reproduction still does not produce year classes comparable in size to stocking 500,000 phase I fingerlings that exhibit good survival.

Striped bass fishing during the peak season was extremely disappointing considering the stocking success of the 1995 and 1996 year classes in Lake Seminole. These two year classes were expected to be fully recruited into the sport fishery and provide good fishing for striped bass. Instead, springtime estimates of catch, harvest, and angling effort were among the worst since 1985. Low effort and catch was originally attributed to extreme flooding in the ACF, however, hybrid effort and harvest estimates were comparable to 1997, indicating that flooding of access areas was not a contributing factor to poor striped bass fishing. Additionally, no trophy-sized striped bass were recorded during the 14-week creel survey. Declining effort toward striped bass is probably related to declining effort toward *Morone* hybrids since the stocking densities have been reduced in Lake Seminole.

Radio and ultrasonic telemetry data indicate that suitable thermal refugia in the LAR or ICW to support age-2 and older striped bass may not be available. The data also suggest that thermal refugia may not be too critical for age-2 fish. However, the smaller of the fish released may yet locate and occupy refugia before the end of the summer. Limited data provided by fish implanted with radio transmitters indicate that these fish may have been disoriented by the relocation, abnormally altering their behavior, and affecting the results. Our inability to locate striped bass with radio transmitters may also be compromised if the fish are utilizing areas influenced by salinity.

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Table 1. Summary of striped bass broodfish collected from the Apalachicola River below Jim Woodruff Lock and Dam during March and April 1998 and distributed to Welaka National Fish Hatchery (Welaka) or Blackwater Fisheries Research and Development Center (BWFRDC).

| Date | Fish No. | TL (mm) | WT (kg) | Sex | Egg Stage | mtDNA | Hatchery Destin'n | Water Temp(F) |
|---|---|---|---|---|---|---|---|---|
| 3/23/98 | 1 | 894 | | F | 3 | D1 | BWFRDC | 60 |
| | 2 | 620 | 3.6 | M | | D1 | WELAKA | 60 |
| | 3 | 760 | 6.8 | M | | C2 | BWFRDC | 60 |
| | 4 | 580 | 2.6 | M | | C(D)2 | WELAKA | 60 |
| | 5 | 648 | 4.8 | M | | B(C)2 | BWFRDC | 60 |
| | 6 | 552 | 2.8 | M | | C2 | WELAKA | 60 |
| 3/30/98 | 10 | 800 | 7.4 | M | | A(B)(A')2 | WELAKA | 66 |
| | 12 | 530 | 2.4 | M | | B2 | WELAKA | 66 |
| | 13 | 840 | 10.2 | F | 4 | B2 | WELAKA | 66 |
| | 16 | | 12.8 | F | 4 | C2 | WELAKA | 66 |
| | 17 | 785 | 10.4 | F | 2 | C2 | WELAKA | 66 |
| | 18 | 583 | 2.8 | M | | C? | WELAKA | 66 |
| 3/31/98 | 19 | 520 | 1.0 | M | | C1 | WELAKA | 67 |
| | 22 | 670 | 5.4 | M | | C1 | WELAKA | 67 |
| | 24 | 554 | 2.6 | M | | C2 | WELAKA | 67 |
| 4/2/98 | 26 | 800 | 10.2 | F | 2 | B(C)1 | WELAKA | 70 |
| | 29 | 630 | 3.8 | M | | D1 | WELAKA | 70 |
| | 30 | 655 | 4.6 | M | | D1 | WELAKA | 70 |
| | 32 | 779 | 8.6 | M | | C1 | WELAKA | 70 |
| 4/6/98 | 36 | 800 | 8.6 | M | | C2 | WELAKA | 69 |
| | 37 | 756 | 6.6 | M | | C1 | WELAKA | 69 |
| | 38 | 625 | 4.4 | M | | B(A)2 | WELAKA | 69 |
| | 45 | 590 | 3.2 | M | | B2 | WELAKA | 69 |
| 4/7/98 | 47 | 700 | 5.8 | M | | C2 | WELAKA | 70 |
| | 48 | 610 | | M | | D1 | WELAKA | 70 |

Table 1. Continued

| Date | Fish No. | TL (mm) | WT (kg) | Sex | Egg Stage | mtDNA | Hatchery Destin'n | Water Temp(F) |
|---|---|---|---|---|---|---|---|---|
| | 49 | 600 | 4.0 | M | | B2 | WELAKA | 70 |
| | 51 | 598 | 3.2 | M | | C1 | WELAKA | 70 |
| | 52 | 640 | 4.2 | M | | D1 | WELAKA | 70 |
| | 53 | 535 | 2.6 | M | | C1 | WELAKA | 70 |
| | 54 | 524 | 2.8 | M | | C2 | WELAKA | 70 |
| | 59 | 717 | 6.0 | F | 3 | D1 | WELAKA | 70 |
| | 60 | 618 | 4.0 | M | | C2 | WELAKA | 70 |
| | 61 | 625 | 4.2 | F | 3 | | WELAKA | 70 |
| | 63 | 890 | 10.8 | F | 4 | -2 | WELAKA | 70 |
| | 65 | 727 | 5.0 | F | 4 | D1 | WELAKA | 70 |
| | 66 | 803 | 7.4 | F | 4 | C2 | WELAKA | 70 |
| 4/15/98 | 81 | 523 | 1.8 | M | | B2 | WELAKA | 68 |
| | 82 | 975 | 16.0 | F | 3 | C2 | WELAKA | 68 |
| | 86 | 824 | 8.8 | M | | C1 | WELAKA | 68 |
| | 88 | 766 | 8.0 | F | 5 | C2 | WELAKA | 68 |
| | 89 | 563 | 2.4 | M | | C(B)? | WELAKA | 68 |
| | 90 | 562 | 2.6 | M | | D1 | WELAKA | 68 |
| | 91 | 552 | 2.4 | M | | C1 | WELAKA | 68 |
| 4/21/98 | 93 | 695 | 6.0 | F | 4 | C2 | BWFRDC | 70 |
| | 94 | 705 | 5.8 | F | 2 | D1 | BWFRDC | 70 |
| | 95 | 780 | 7.2 | F | 4 | A(A')2 | BWFRDC | 70 |
| | 97 | 870 | 10.0 | F | 3 | A(C)2 | BWFRDC | 70 |
| | 98 | 1020 | 20.2 | F | 4 | C1 | BWFRDC | 70 |
| | 99 | 905 | 11.8 | F | 5 | A(A')2 | BWFRDC | 70 |

Number of females sent to hatcheries - 19

Number of males sent to hatcheries - 21

Number of fish released - 59

Table 2. Mitochondrial DNA samples from YOY striped bass collected by electrofishing in Lake Seminole, Apalachicola River, Lake Blackshear and the Flint River, 1997.

| Month | TL (mm) | WT (g) | mtDNA Genotype | Month | TL (mm) | WT (g) | mtDNA Genotype |
|---|---|---|---|---|---|---|---|
| **Lake Seminole** | | | | **Lake Seminole continued** | | | |
| Sept. | 122 | 20 | C-1 | Oct. | 145 | 30 | C(B)1 |
| Sept. | 140 | 28 | D-1 | Oct. | 162 | 45 | D-1 |
| Sept. | 165 | 58 | D-1 | Oct. | 153 | 40 | C-1 |
| Sept. | 119 | 16 | C-1 | Oct. | 164 | 47 | C(D)1 |
| Sept. | 125 | 20 | B(A′)(A)2 | Oct. | 154 | 42 | A(B)2 |
| Sept. | 130 | 22 | D-1 | Oct. | 153 | 36 | D-1 |
| Sept. | 125 | 20 | B(A′)(A)2 | Oct. | 163 | 46 | B(A)2 |
| Sept. | 131 | 22 | C-1 | Oct. | 162 | 46 | C-1 |
| Sept. | 134 | 24 | D-1 | Oct. | 142 | 38 | A(B)2 |
| Sept. | 157 | 40 | D-1 | Oct. | 172 | 60 | B(C)1 |
| Sept. | 169 | 44 | C-1 | Oct. | 149 | 36 | C-2 |
| Sept. | 194 | 184 | C-2 | Oct. | 147 | 34 | A′(B)2 |
| Sept. | 133 | 26 | D-1 | Oct. | 132 | 28 | A′(B)(A)2 |
| Sept. | 160 | 44 | C-1 | Oct. | 172 | 56 | C-1 |
| Sept. | 140 | 28 | B(D)(A)2 | Oct. | 170 | 56 | C-1 |
| Sept. | 135 | 22 | C-1 | Oct. | 151 | 38 | D-1 |
| Sept. | 135 | 24 | C-2 | Oct. | 172 | 50 | C-1 |
| Sept. | 153 | 32 | C-1 | Oct. | 174 | 60 | C(B)2 |
| Sept. | 153 | 34 | C-1 | **Apalachicola River** | | | |
| Sept. | 165 | 46 | C-1 | Sept. | 163 | 43 | C-1 |
| Sept. | 195 | 70 | B(C)2 | Sept. | 169 | 56 | C-1 |
| Sept. | 188 | 76 | B-2 | Oct. | 170 | 56 | C-1 |
| Sept. | 131 | 24 | C-2 | Oct. | 193 | 78 | D-1 |
| Sept. | 151 | 38 | C-1 | Oct. | 158 | 42 | D-1 |
| Sept. | 145 | 30 | C-1 | Oct. | 212 | 96 | C-1 |
| Oct. | 194 | 88 | B(C)2 | Oct. | 195 | 90 | C-2 |

Table 2. Continued

| Month | TL (mm) | WT (g) | mtDNA Genotype | Month | TL (mm) | WT (g) | mtDNA Genotype |
|---|---|---|---|---|---|---|---|
| **Apalachicola River continued** | | | | **Apalachicola River continued** | | | |
| Sept. | 135 | 34 | D-1 | Oct. | 173 | 60 | D-1 |
| Sept. | 160 | 50 | C-2 | Oct. | 164 | 54 | C-2 |
| Sept. | 133 | 28 | C-1 | Oct. | 141 | 32 | B(A′)2 |
| Sept. | 153 | 38 | C-1 | Oct. | 137 | 34 | D-1 |
| Sept. | 161 | 46 | C(B)1 | Oct. | 141 | 30 | D-1 |
| Sept. | 135 | 28 | C-1 | Oct. | 136 | 30 | A′(B)(A)2 |
| Sept. | 160 | 58 | C-1 | Oct. | 131 | 25 | B(A′)2 |
| Sept. | 125 | 22 | C-2 | **Lake Blackshear** | | | |
| Sept. | 128 | 21 | C-2 | Oct. | 115 | 125 | (A)(B)(C)2 |
| Sept. | 111 | 16 | B-2 | Oct. | 96 | 8 | A(B)2 |
| Sept. | 151 | 39 | A-2 | Oct. | 140 | 27 | A(B)2 |
| Oct. | 130 | 22 | B-2 | Oct. | 157 | 43 | (A)(B)(C)2 |
| Oct. | 133 | 26 | D-1 | Oct. | 170 | 52 | (A)(B)(C)2 |
| Oct. | 148 | 34 | C-2 | Oct. | 221 | 138 | A(B)2 |
| Oct. | 216 | 111 | C-1 | Oct. | 242 | 186 | A(B)2 |
| Oct. | 193 | 84 | C-1 | **Flint River** | | | |
| Oct. | 187 | 64 | C-2 | Oct. | 200 | — | C-1 |
| Oct. | 185 | 80 | C-1 | Oct. | 158 | — | C-1 |
| Oct. | 171 | 70 | B(A′)(A)2 | Oct. | 158 | — | C-1 |

Table 3. Total number and 72-hour survival estimates of phase I Gulf striped bass stocked into Lake Seminole, 1998.

| Date | Location | Total Number | 72 Hr Survival | Adjusted Stocking Number |
|---|---|---|---|---|
| 5/8/98 | Lk Seminole | 91,400 | *No Estimate | *91,400 |
| 5/21/98 | Lk Seminole | 63,000 | 100% (N=25) | 63,000 |
| 5/25/98 | Lk Seminole | 60,000 | *No Estimate | *60,000 |
| 5/28/98 | Lk Seminole | 80,100 | 99% (N=75) | 79,343 |
| 5/29/98 | Lk Seminole | 40,000 | 0% (N=35) | 0 |
| 5/98 | Lk Seminole | 82,000 | *No Estimate | *82,000 |
| 6/11/98 | Lk Seminole | 87,000 | 98% (N=50) | 85,260 |
| 6/98 | Lk Seminole | 30,000 | *No Estimate | *30,000 |
| Total | | 533,500 | | 491,003 |

*No Estimate - Survival through 72 hours was assumed to be 100%.

Table 4. Total number, 72-hour survival estimates, and adjusted number of phase II striped bass released into the lower Apalachicola River and Intracoastal Waterway from October 1997 to February 1998.

| Date | Total Number | 72-Hour Survival (%) | Adjusted Stocking Number |
|---|---|---|---|
| 10/17/97 | 9,787 | 94 | 9,200 |
| 12/2/97 | 2,200 | 59 | 1,298 |
| 12/9/97 | 3,385 | 63 | 2,133 |
| 12/9/97 | 7,152 | 97 | 6,937 |
| 12/16/97 | 4,830 | 46 | 2,222 |
| 12/17/98 | 1,989 | 53 | 1,054 |
| 12/17/97 | 1,904 | 66 | 1,257 |
| 12/19/97 | 2,046 | 95 | 1,944 |
| 12/19/97 | 2,071 | 66 | 1,367 |
| 1/7/98 | 1,860 | 100 | 1,860 |
| 1/8/98 | 1,215 | 100 | 1,215 |
| 1/14/98 | 1,587 | 50 | 794 |
| 1/24/98 | 2,277 | 85 | 1,935 |
| 1/24/98 | 1,560 | 87 | 1,357 |
| 1/27/98 | 1,803 | 43 | 775 |
| 1/27/98 | 1,500 | 86 | 1,290 |
| 1/30/98 | 1,580 | 100 | 1,580 |
| 1/30/98 | 1,575 | 80 | 1,260 |
| | 50,321 | $\bar{x}$ = 76(SE=4.57) | 39,478 |
| Remainder Stocked: | | | |
| | 81,036 | | 61,587 |
| Grand Total | 131,357 | | 101,065 |

Table 5. Harvest, effort (hours) and success (number per hour) estimates for the Jim Woodruff Lock and Dam tailwater creel survey, February - May 1998. SE denotes one standard error.

| | Number | SE | Effort (Hrs) | SE | Success | SE |
|---|---|---|---|---|---|---|
| Striped Bass | | | | | | |
| Total Catch | 364 | 74 | 1,593 | 380 | 0.19 | 0.09 |
| Harvest | 297 | 49 | | | 0.15 | 0.07 |
| Morone Hybrid | | | | | | |
| Total Catch | 2,090 | 461 | 4,396 | 798 | 0.52 | 0.23 |
| Harvest | 1,989 | 393 | | | 0.50 | 0.23 |
| Largemouth Bass | | | | | | |
| Total Catch | 158 | 49 | 175 | 58 | 0.20 | ---- |
| Harvest | 62 | 50 | | | 0.01 | ---- |
| Sunfish | | | | | | |
| Harvest | 17,475 | 3,022 | 7,560 | 1,270 | 2.33 | ---- |

Table 6. Summary of radio (R) and sonic (S) tagged striped bass released at four locations (Old Woman Bluff [OWB] [NM 5.0], East River [ER] [Gardner Landing], Gulf County Canal [GCC] and Searcy Creek [SC])in the Apalachicola River System, Florida, through June 30, 1998.

| Tag No. | TL (mm) | WT (kg) | Transmitter | Release Location | Release Date | No. of Locations | Locations in Cool $H_2O$ |
|---|---|---|---|---|---|---|---|
| 601 | 562 | 2.0 | R | ER | 4/27/98 | 0 | 0 |
| 622 | 526 | 2.0 | R | OWB | 4/27/98 | 6 | 0 |
| 631 | 465 | 1.4 | R | ER | 4/27/98 | 2 | 0 |
| 650 | 514 | 1.8 | R | OWB | 4/27/98 | 5 | 0 |
| 670 | 542 | 2.4 | R | ER | 4/27/98 | 2 | 0 |
| 690 | 552 | 2.3 | R | OWB | 4/27/98 | 3 | 0 |
| 700 | 530 | 2.0 | R | ER | 4/27/98 | 1 * | 0 * |
| 720 | 549 | 2.4 | R | OWB | 4/27/98 | 5 | 0 |
| 741 | 530 | 2.3 | R | ER | 4/27/98 | 0 | 0 |
| 750 | 456 | 1.0 | R | OWB | 4/27/98 | 14 | 0 ** |
| 249 | 487 | 1.6 | S | GCC | 4/27/98 | 6 | 2 |
| 258 | 445 | 1.1 | S | GCC | 4/28/98 | 17 | 0 |
| 285 | 445 | 1.2 | S | GCC | 4/27/98 | 6 | 0 |
| 294 | 430 | 1.0 | S | GCC | 4/27/98 | 9 | 0 ** |
| 339 | 411 | 1.1 | S | GCC | 4/27/98 | 18 | 0 *** |
| 348 | 412 | 1.0 | S | GCC | 4/27/98 | 18 | 0 |
| 357 | 519 | 1.6 | S | GCC | 4/27/98 | 3 | 0 |
| 366 | 565 | 2.7 | S | GCC | 4/27/98 | 4 | 3 |
| 447 | 552 | 2.7 | S | SC | 4/28/98 | 3 | 3 |

* Intermittent signal on this frequency at Jim Woodruff Lock & Dam.

** Caught by angler at dam June 15, 1998.

*** Presumed dead.

# <u>Reproductive Success of Stocked Striped Bass, *Morone saxatilis*, in the Chattahoochee River Above West Point Reservoir: Implications for the *Morone* Stocking Program</u>

*Cecil Jennings, Biological Resources Division, U.S. Geological Survey*

## Introduction

Interest in a trophy striped bass fishery in West Point Lake resulted in the stocking of a small number of stripers on an experimental basis. In 1990, Georgia Department of Natural Resources (GDNR) stocked about 25,000 one inch fingerlings (rate = 1 per acre); in 1992, the lake received an additional 176,400 once inch fingerlings (rate = 7 per acre). The relatively low (compared with the hybrid striped bass) stocking rate was an attempt to ensure that these stripers did not pose a threat to the trout fishery that exists in the Chattahoochee River below Morgan Falls Dam. A self-sustaining striped bass population in West Point Lake means GDNR cannot control the size of this population and raises concerns that some stripers will migrate upstream and eventually decimate a trophy trout (rainbow and brown) fishery in the trout waters of the upper Chattahoochee River (i.e., Morgan Falls Dam downstream to the I-285 bridge).

The reproductive status of two year classes (1990 and 1992) of striped bass stocked into West Point Lake is unknown; however, anecdotal reports suggest that these fish may be reproducing successfully in the Chattahoochee River upstream of the lake. GDNR samples fish populations in the system routinely, but efforts to assess the reproductive status of striped bass in the lake or in the river have not been undertaken. Information on the reproductive status of this population is needed to formulate management strategies to better maintain state-sponsored sport fisheries in West Point Reservoir and the Chattahoochee River above the lake. Therefore, this project was undertaken to determine if striped bass stocked in West Point Reservoir are reproducing naturally in the Chattahoochee River upstream of the reservoir.

## Methods

Sampling for striped bass eggs and larvae was conducted during the spring at three locations along the Chattahoochee River between the reservoir and Atlanta, Georgia (Figure 1). Station 3 was located in the vicinity of Franklin Shoals, adjacent to the town of Franklin, Georgia. Station 2 was located just upstream of the Highway 166 bridge, near the west side of Atlanta. Sampling was to begin when water temperature reached 15°C and continue until water temperature reached or exceeded 23°C for five consecutive days. After the river warmed to 13°C, water temperature was monitored daily by personnel at Georgia Power Company's Plant Vogle, which is located just downstream of Station 2. Water temperature at this location reached 15°C during the last week of March. Therefore, drift sampling at all stations was begun the following week.

Ichthyoplankton drift in the study reach was sampled three times a week beginning on April 1, 1998 (water temperature = 18.9°C) and continued for about eight weeks to May 29, 1998 (water temperature reached 23°C on May 25, 1998). At each station, a 0.5 m diameter plankton net (mesh = 505µ) fitted with a General Oceanics® flow meter was used to take three samples of ichthyoplankton drift. The samples were stored in 1 liter plastic jars, preserved in formalin, and returned to the laboratory for processing. Two samples from each station were stored in 7% unbuffered formalin with Eosin + Biebrich Scarlet stain added; the third was stored in 100% ethanol. The ethanol-stored samples will be used to determine the genetic origin of any striped bass eggs or larvae found. Water temperature and dissolved oxygen were measured with a YSI® dissolved oxygen/temperature meter. Depth was measured with a boat-mounted Lowrance depth finder. Current velocity was measured with a Marsh-McBirney® flow meter, and turbidity was measured with a Hach® portable turbidimeter.

Laboratory processing of the drift samples is still ongoing. Processing includes extracting eggs and larvae from the drift samples. Striped bass eggs and larvae will be identified and enumerated to determine density in the drift (number per cubic meter of water). Any striped bass eggs found will be aged to determine when and where they were spawned.

**Results**

Two hundred fourteen individual samples (of about 100 $m^3$ of water each) were taken from the study reach during the eight-week sampling period. To date, 89 of those samples (about 40%) have been processed. The last sample processed to date was collected on April 29, 1998, and water temperatures at the three stations that day were 11.8, 13.5, and 15.6°C, respectively. Thirty-five of the 89 samples processed (39%) did not contain fish or eggs. The remaining fifty-four samples contained 215 eggs and 37 larval fishes. None of the eggs or larvae collected as of April 29$^{th}$ appear to be striped bass. A total of 20 larval fishes from 11 different samples have been identified: 16 (80%) were larval spotted suckers *Minytrema melanops*, three (15%) were shiners (i.e., *Notropis* spp and *Notemigonus* sp.), and one (5%) was too damaged to be identified reliably.

Water temperature in the study reach fluctuated around 15°C for much of the spring, and the date at which water temperature at each station was warm enough to trigger spawning was progressively later with distance upstream from the reservoir. For example, Station 1 was furthest upstream from the reservoir, and water temperature there was below 15°C on May 13, 1998; on the same day, water temperatures at Station 2 and 3 were 16.1 and 18.1°C, respectively (Figure 2). In another instance (April 24), water temperature at all three stations ranged from 12.3-13.3°C (Figure 2). Nonetheless, once water temperature at the station nearest to the reservoir (i.e., Station 3) reached 15°C sampling began. Samples of ichthyoplankton drift were collected at all stations to ensure that eggs from any potential spawning events would not be missed.

**Discussion**

The gear used to sample ichthyoplankton drift from the study reach was effective in sampling eggs and larvae. Therefore, passively-drifting eggs and pro-larvae of striped bass would be vulnerable to the gear used in the study. The absence of striped bass eggs or larvae from the samples processed to date suggest that the adults are not spawning in the river as of April 29, 1998. The lack of spawning may be related to limitations in the length of the un-impounded reach upstream of the reservoir and the resulting hydrologic regime or may be related to the absence of environmental conditions (e.g., temperature ≥ 15°C) necessary to trigger spawning. Which of these two factors is responsible for the results obtained thus far is unknown. However, the relatively cool temperatures of the water from which the small number of processed samples were taken suggest that any potential spawning by adult striped bass in the Chattahoochee River above West Point Reservoir probably was delayed or sporadic. Processing of the remaining samples that were taken later in the spring should be helpful in resolving this issue.

Sample processing has proceeded more slowly than expected, primarily because of large amounts of leaf litter and other suspended materials in the drift. This condition was especially acute at Station 2, where two 1 liter sample jars usually were needed to hold the volume of material collected in the net (most other samples filled only one 1 liter jar). Consequently, only about 40% of the samples collected have been processed to date. Two remedies have been adopted to resolve this situation. First, a part-time technician was hired to help with sample processing. Secondly, the remaining unprocessed samples will be subsampled (i.e., only one of the three replicates from each station will be processed) to expedite the processing of samples taken later in the spring when water temperatures were warmer. This second step was undertaken to pinpoint temporally and spatially any potential spawning events. Eventually, all the samples collected during the spring of 1998 will be processed.

The results presented here are preliminary and should not be used to estimate the abundance of striped bass eggs or larvae in the study reach or to make inferences about the reproductive status of adults in West Point Reservoir. The sampling protocol used to collect ichthyoplankton drift (i.e., station location and sampling frequency) was designed so that eggs spawned anywhere in the study reach would be vulnerable to the sampling gear, and the gear used was effective at sampling passively drifting eggs and larvae. Therefore, the completion of the sampling processing should provide a more definitive answer to the question of whether striped bass in West Point Reservoir are reproducing successfully in the Chattahoochee River above the reservoir.

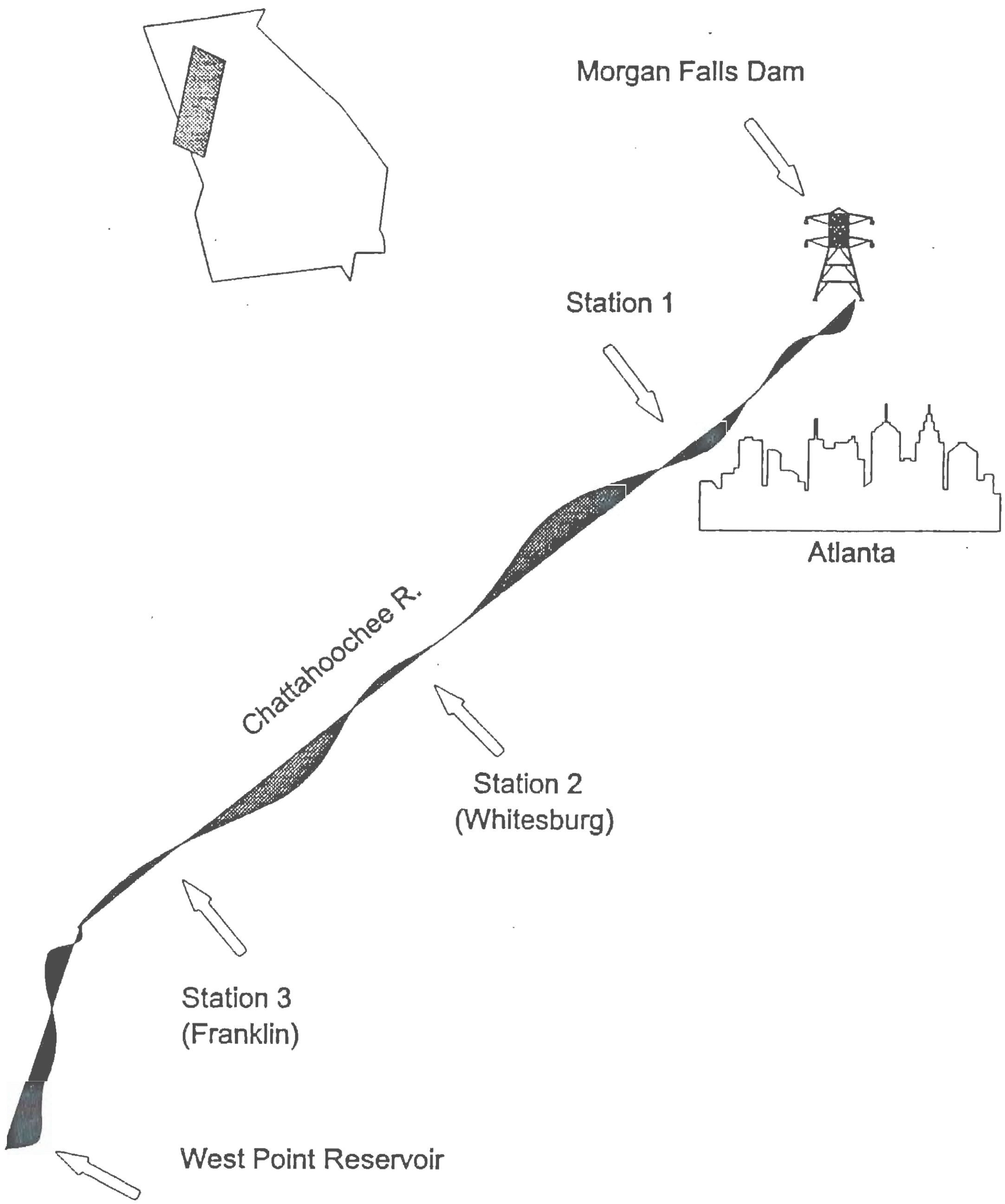



Figure 1. Map showing the State of Georgia and the approximate location of the study reach of the Chattahoochee River (as indicated by the gray-stippled area) sampled during Spring 1998, the approximate location of the three sampling stations, the barrier to upstream migration (i.e., Morgan Falls Dam), and the beginning of West Point Reservoir.

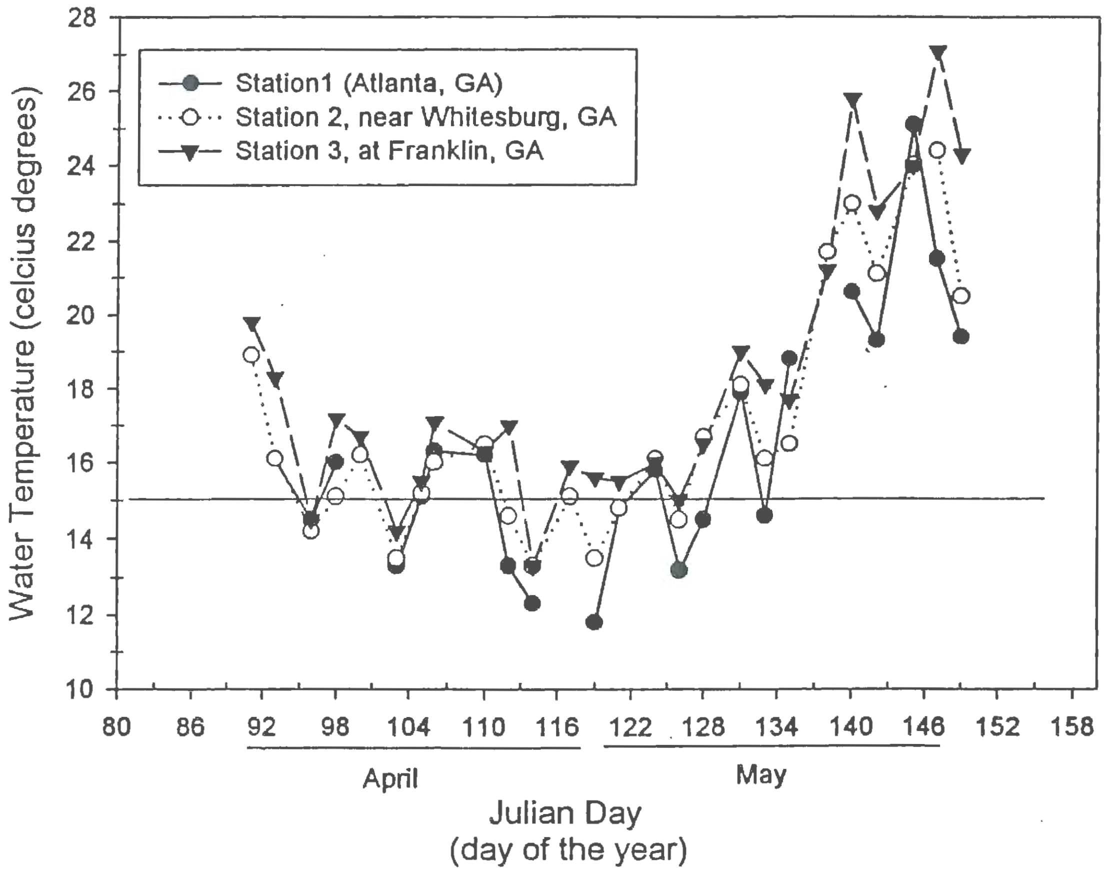



Figure 2. Range of water temperatures (°C) measured at the sampling station in the study reach of the Chattahoochee River from during Spring 1998. The horizontal line represents the 15 °C isopleth.

## Striped Bass Investigations in the Pearl and Tchefuncte Rivers

*Howard Rogillio, Louisiana Department of Wildlife and Fisheries*

### Objective

The objectives of this project are to determine if thermal refugia exist in the Pearl River System and to compare the stocking success of phase I and phase II fingerlings in the Pearl River.

Job 1. Striped Bass Stocking and Evaluation

Phase 1: Stocking of phase I fish and electrofishing five weeks later to evaluate success.

Work Accomplished: On June 11, 1997, 25,200 Gulf Coast striped bass, phase I fish were stocked in the West Pearl River at Lock I approximately 2 miles below the dam. At that time 105 fingerlings were placed in a live box and observed for three days. See Table 1 for mortality results.

On July 22, 1997, we began sampling for the phase I striped bass fingerlings using electrofishing gear. After three unsuccessful electrofishing trips, we began using a 50 ft. bag seine. Samples starting two hours before sunset and continued until two hours after sunset. Table 2 shows potential phase I striped bass fingerlings we captured near the release area.

The striped bass collected were forwarded to NYU Medical Center for genetic classification. No results have come back.

Various problems developed during the first year that affected the direction of activities, after which we decided to adjust our methods and shifted our study location. Our first problem was obtaining an I.N.A.D. permit to feed oxytetracycline to phase II fish. Oxytetracycline would help us distinguish phase I from phase II fish by staining the otolith. It was impossible to get a permit to feed phase II fish with oxytetracycline. We did get permission to dip Gulf strain fish at Inks Dam Hatchery. However, the fry did not survive the treatment. That compelled us to use two separate genotypes of Gulf strain striped bass in order to differentiate between phase I and phase II fish. Since the Mississippi Department of Wildlife, Fisheries, and Parks was also stocking the Pearl River System with Gulf strain striped bass, we concluded that we must change river systems. The Tchefuncte River was chosen because we were confident we controlled the stocking in that river, and it was known to support a striped bass fishery.

Forty-five thousand five hundred seventy (45,570) Gulf striped bass were stocked in the Tchefuncte River and Bogue Falaya River on June 3, 1998. A total of 62 striped bass were captured using a 50 foot seine during the five consecutive weeks of sampling (Table 2).

Phase II: Stock 5000 phase II striped bass were to be marked with tetracycline and stocked in the Pearl River system.

Work Accomplished: Our objective was to mark phase II fish with oxytetracycline to differentiate stocking success of phase I and phase II fish. However, we encountered a major stumbling block in obtaining and I.N.A.D. permit to administer this drug to our phase II fish. The permit could not be obtained at any cost. An alternative tagging method was substituted. We used a magnetic wire tag injected into the right cheek of the phase II stripers.

On December 9, 1997, we received approximately five thousand phase II fish from Inks Dam National Fish Hatchery. Fish were placed in six large round holding tanks at our Booker Fowler Hatchery. On December 10 we sedated the phase II fish with MS222 and began to inject the wire tags. On December 11, 1997, the phase II fish were stocked on the West Pearl River at the same location as the phase I fish. Mortality appeared to be heavy.

Two hundred phase II fish were placed in a hatchery pond. One hundred of these were dipped into an oxytetracycline solution. We were going to remove the fish in the summer and check for tag retention. Two weeks later we were informed by our hatchery personnel that all the fish died.

**Evaluation: Search for Striped Bass**

A total of 268 net hours was fished attempting to locate striped bass and their habitat. The Tchefuncte River, Bogue Chitto River, Pearl River and Lake Pontchartrain were all sampled in an effort to acquire striped bass (Table 3). Six adult striped bass were snared in gill nets. Four were acquired at the Bogue Chitto River using rod and reel. Fourteen juveniles were captured on the Pearl River using a seine in June of 1997. This year we caught an additional 49 juveniles while seining on the Bogue Falaya River.

Job 2. Striped Bass Habitat Surveys

Work Accomplished: April 21, 1998 we tagged our first striped bass with a radio tag. This fish was a female that was 712 mm in length and weighed 4938 g. The capture site was just north of I-12 bridge on the Little Tchefuncte River (30° 27.761 N - 90° 06.958). The second fish was caught April 22, 1998 just north of I-12 bridge. This male striped bass weighed 3146 g. and was 605 mm in length. Both fish appear to be surviving and are being tracked weekly. They have continued to move in and out of our range.

Job 3. Fishermen Information

Work Accomplished: Forty-six fishermen were interviewed during the year. Fourteen reported that they had aggressively fished for striped bass.

Table 1
Mortality rate of Phase I fish held in live car for 72 Hours after stocking

| Date | Mortality | River Temp. Degrees F° |
|---|---|---|
| June 12, 1997 | 3 Died | 79° |
| June 13, 1997 | 0 Died | 79° |
| June 14, 1997 | 3 Died | 81° |
| | | Released 99 of 105 (94.28% survival |
| June 4, 1998 | | 81° |
| June 5, 1998 | | 82° |
| June 6, 1998 | 4 Died | 83° |
| | | Released 96 of 100 (96% survival) |

Table 2
List of potential Phase I striped bass - captured five weeks after stocking

| Date | Location | # Striped Bass | Size Range |
|---|---|---|---|
| 7-22-97 | below lock I to I-59 | 0 | 0 |
| 7-31-97 | I-59 to Davis landing | 0 | 0 |
| 8-5-97 | Crawford landing to Hwy. 190 | 0 | 0 |
| 8-19-97 | West Pearl river @ Nav, Canal Lock I | 1 before sunset | 70 mm |
| 8-13-97 | West Pearl river @ Nav, Canal Lock I | 4 before sunset<br>2 after sunset | 89-115 mm |
| 7-08-98 | Bogue Falaya River | 7 before sunset<br>0 after sunset | 80-90 mm |
| 7-14-98 | Bogue Falaya River | 18 before sunset<br>13 after sunset | 58-110 mm |
| 7-21-98 | Bogue Falaya River | 0 before sunset<br>13 after sunset | 84-109 mm |
| 7-29-98 | Bogue Falaya River | 2 before sunset<br>2 after sunset | 74-104 mm |
| 8-06-98 | Bogue Falaya River | 1 after sunset | 101 mm |

**Table 3**
Record of striped bass harvested

| LENGTH (mm/in) | WEIGHT (g./lbs.) | Location (River) | DATE | GEAR (net, hook-n-line) |
|---|---|---|---|---|
| 655<br>25.78 | 5035<br>11.1 | Lake Pontchartrain | 2-13-98 | gill net |
| 656<br>25.82 | 4312<br>9.5 | Tchefuncte River | 4-2-98 | gill net |
| 745<br>29.33 | 7004<br>15.44 | Tchefuncte River | 4-2-98 | gill net |
| 675<br>26.57 | 4962<br>10.94 | Tchefuncte River | 4-2-98 | gill net |
| 712<br>28.03 | 4938<br>10.89 | Little Tchefuncte River | 4-21-98 | gill net<br>radio tagged |
| 605<br>23.82 | 3146<br>6.94 | Little Tchefuncte River | 4-22-98 | gill net<br>radio tagged |
| 464<br>18.27 | 1260<br>2.78 | Bogue Chitto sill | 7-7-98 | hook-n-line |
| 421<br>16.57 | 841<br>1.85 | Bogue Chitto sill | 7-7-98 | hook-n-line |
| 451<br>17.76 | 963<br>2.12 | Bogue Chitto sill | 7-7-98 | hook-n-line |
| 460<br>18.11 | 1090<br>2.40 | Bogue Chitto sill | 7-7-98 | hook-n-line |

## Population Characteristics of Striped Bass in the Pearl River and Lake Pontchartrain Tributaries

*Fred Monzyk, Louisiana State University*

### Objectives

To determine age structure, length-frequency, growth rate, and mortality rate of the striped bass population in the Pearl River.

To determine changes in condition indices and reproductive status relative to time of year and fish size.

### Accomplishments

Sampling Effort - Fish sampling trips were carried out on sixteen separate occasions from 10 October 1997 through 26 August 1998 in an effort to collect striped bass. All sampling efforts were conducted in the Washington and St. Tammany Parishes, Louisiana, with gillnets and hook and line sampling in the Pearl River system and in the Tchefuncte River system. Total effort consisted of 7,975 ft. of experimental gillnet (fish for 24-hour periods) and 132 angler-hours of hook and line sampling. Of the total gillnet effort, 2800 ft. was employed in the Tchefuncte River system from 8 April 1998 to 12 May 1998 and the remainder at various locations in the Pearl River. Hook and line sampling was concentrated below two low-head dams on the Pearl and Bogue Chitto Rivers near the Pearl River Navigation Canal. To date, 50 striped bass have been collected. The majority (n = 36) were collected via hook and line below the dam on the Bogue Chitto River (a Pearl River tributary). Five striped bass were collected with gillnets in the Tchefuncte River system. Additionally, 584 other fishes comprising 32 species were collected with gillnets in the two river systems.

Age and Growth - The 50 striped bass ranged in size from 322-720 mm TL and were from age 1 to age 4. Preliminary analysis of back-calculated growth indicated that first years growth appears to be very good (Table 1). The only populations of striped bass found in the literature with average age 1 growth similar to this were those stocked into Florida lakes (282mm TL; Ware 1971).

Table 1. Back-calculated lengths for the fifty striped bass collected to date.

| | Age-1 | Age-2 | Age-3 | Age-4 |
|---|---|---|---|---|
| Back-calculated length (mm TL) | 288 n =50 | 433 n=20 | 571 n=5 | 619 n=2 |

Condition - Relative weight (Wr) for the fifty striped bass averaged 92.4 and tended to increase slightly during the spring months (Figure 1). The liver-somatic index averaged 1.14 and showed a similar trend (Figure 2). The gonadosomatic index peaked in the month of April indicating that spawning most likely occurs at this time.

Sex Ratios
Males: n=29 (58%)
Females: n=21 (42%)

Fecundity - Fecundity estimates were calculated for two gravid females caught in gillnets in the Tchefuncte River system (Table 2).

Table 2. Fecundity estimates calculated for striped bass collected in the Tchefuncte River. Estimates were made with the gravimetric method.

| Fish | Date Collected | Length (mm TL) | Fish Weight (g) | Ovary Wt.(g) | Mean Egg Diameter (mm) | Fecundity Estimate (#egg) |
|---|---|---|---|---|---|---|
| 1 | 4/8/98 | 720 | 6484 | 888 | 0.848 | 2,335,363 |
| 2 | 5/1/98 | 699 | 5106 | 753 | 0.878 | 2,315,653 |

Discussion - Striped bass tend to congregate behind the low-head dams on the Pearl River system during late fall/early winter. Turbulent flows in these areas preclude other forms of sampling in these areas other than hook and line. Hook and line sampling will continue and, when flows subside, electrofishing and gillnetting will be employed in this area, if feasible. Large adults appear in the Tchefuncte River system in the spring and may be attempting to spawn in these waters. The five striped bass collected in the Tchefuncte were over 516 mm TL and at least three years of age. Anglers reported catching large striped bass in Tchefuncte near Covington, Louisiana between April and May. It appears that these fish stay in this system for only a brief time each year and may move to other more suitable areas as water temperatures increase.

Sampling will continue in these and other areas suspected to be good striped bass habitat. Collection of striped bass will be continued throughout the year for further age and growth analysis and to determine trends in condition indices and spawning times.

**Citations**

Ware, F. J. 1971. Some early life history of Florida's inland striped bass, *Morone saxatilis*. Proc. 24th Annual Conference of Southeast Assoc. Game Fish Comm. 1970:439-447.

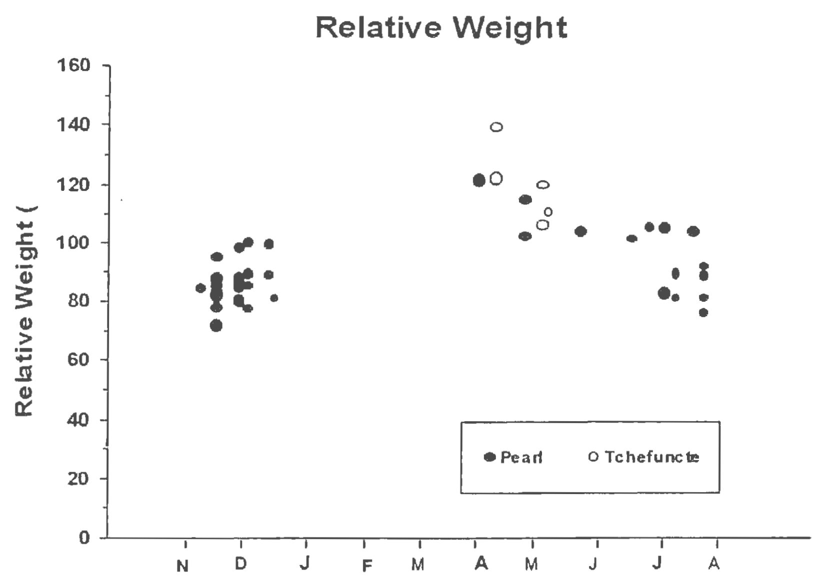



Figure 1. Trend in relative weight

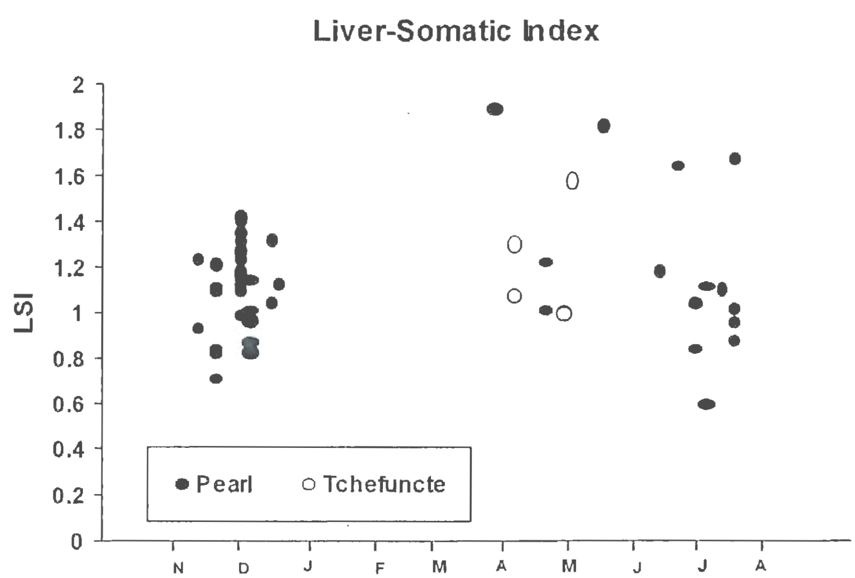



Figure 2. Trend in liver-somatic index.

# Comparative Intensive Culture and Comparative Stocking in the Pascagoula River System of Gulf and Atlantic Striped Bass

*Larry Nicholson, Gulf Coast Research Laboratory*


## Abstract

The primary objective of this project was to compare the survival and growth of Atlantic and Gulf race striped bass in order to determine the race of fish exhibiting the best physiological fit to coastal tributaries of the Northern Gulf of Mexico. To attain the objective, both phase I and phase II fingerling striped bass were reared in intensive culture systems at the Gulf Coast Research Laboratory. The phase I fish were stocked as 50 mm fingerlings, and the 150 mm phase II fish were tagged prior to stocking. For this project all striped bass fingerlings were released in the Pascagoula River System.

Secondary objectives of the project included: (a) soliciting tag return information by conducting interviews with fishermen and fish-camp operators; (b) distributing posters; (c) preparing news releases describing the stocking program, and (d) analyzing tag return data to determine survival, growth, and distribution of stocked fish. All of these efforts proved successful to a degree. These data indicate that striped bass are commonly caught in the Pascagoula River System.


## Introduction

The Gulf Coast Research Laboratory (GCRL) initiated a striped bass restoration program in coastal tributaries of Mississippi in 1969. The primary objective of the project is to restore striped bass to coastal Mississippi by stocking phase I and tagged phase II fingerlings. To attain this objective, fry were obtained from the Marion Fish Hatchery in Alabama. The fish were stocked in the intensive culture tanks at GCRL. They remained in the system until they had attained an average total length exceeding 50 mm. Phase I culture in 1997 lasted 78 days. Survival for the period averaged 31%. A total of 167,271 phase I fingerlings weighing 205 kg were harvested, and 141,267 were released. Twenty-six thousand and four (26,004) phase I fingerlings were restocked into the intensive culture system for phase II culture. At the end of phase II culture (181 days), fourteen thousand eight hundred fifteen (14,815) were harvested. Survival for second culture period was 60%. The striped bass weighed a total of 778 kg. They averaged 52.4 g wet weight and 163.3 mm in total length. The fingerlings were harvested, tagged with t-bar tags, transported to the release sites in coastal Mississippi, and released.

In addition to the primary project objective, secondary objectives for the program included: (a) soliciting tag return information by conducting interviews with fishermen and fish-camp operators; (b) distributing posters; (c) preparing news releases describing the stocking program, and (d) analyzing tag return data to determine survival, growth, and distribution of stocked fish.

## Purpose

This project compares the survival and growth of Atlantic and Gulf race striped bass in order to determine the race of fish exhibiting the best physiological fit to cope with the environmental conditions in tributaries of coastal Mississippi. A precursor of the objective is to compare the survival and growth of the two races under intensive culture conditions at GCRL. The race of striped bass demonstrating superiority in the comparisons could make a significant contribution toward achieving the ultimate objective of restoring a self-sustaining population of striped bass to coastal tributaries of the Northern Gulf of Mexico.

## Methods and Materials

The semi-closed recirculating system consisted of nine rearing units in1997. Eight of the nine units (A through F, and H and I) consisted of 15,120 l fiberglass raceways (9.14 m x 1.83 m x 0.91 m) connected to 3,780 liter circular fiberglass tanks (2.44 m in diameter) that served as biological filters. The ninth system (G) was a 26,460 liter circular fiberglass tank 6.1 m in diameter. This rearing tank was connected to three 1,890 liter circular fiberglass tanks 1.83 m in diameter, which served as biological filters.

The updraft, biological filters were the mainstays of each recirculation system. Each filter unit consisted of either multiple 1,890 liter tanks, like G-system, or one tank with a capacity of 3,780 liters. A perforated, corrugated, fiberglass panel, which served as a water deflector, was placed on the bottom of each filter tank. Approximately 20 cm of thoroughly washed clam shells (Rangia sp.) was placed on top of the deflector. This was the case for all the systems with the exception of H & I. The biological filters for H & I systems consisted of circular fiberglass tanks with a capacity of 3,780 liters. A three inch PVC pipe carried water from the rearing tank to the filter and entered the filter approximately 25.4 mm from the bottom. The 76.2 mm pipe was perforated and fitted with perforated lateral pipes to distribute water equally through the filter media. The filter media consisted of approximately 318 mm of pea gravel.

Water circulation was the same through all nine semi-closed intensive culture systems. It was introduced into the rearing tanks by a sump pump. Water flowed through the rearing tanks, passed through the 505-mesh Nitex (TM) netting covering the openings on the standpipe tubes, and then flowed up and over standpipes where it was collected in a common drain. The drain pipe carried the water to the updraft biological filter(s). Water flowed up through the filter, and overflowed from the filter into the sump were the pump repeated the process. The rate of circulation and the aeration of filtered water were controlled by spraying a portion of the water back into the sump by a valved return line. In-line valves located along the side of each rearing tank were used to regulate the volume of the input water. To prevent the water flow from impinging the feebly swimming fry on the Nitex netting, each standpipe tube was fitted with an air ring. The ring was attached to the tube just below the covered openings. The very fine air bubbles from the air ring created a bubble curtain that helped prevent brine shrimp nauplii from being swept down the drain, and striped bass fry from being impinged on the Nitex screen. The bubbles also alleviate some debris from collecting on the venturi screens. Water used to fill the rearing units was obtained from Davis Bayou and a fresh water well. This mixture of water was also used to replace that drained from the systems each day while back-flushing the bio-filters. Prior to introduction into the rearing systems, the naturally buffered bayou water was pumped into a 45,360 liter open settling tank. Chlorine was added to the water at the rate of 1 part per million (ppm) and allowed to settle for 24 hours. The chlorine killed most of the indigenous organisms pumped into the settling tank from the bayou and also aided in the flocculation of suspended particles. Sunlight and subsequent aeration were employed to dechlorinate the treated water. After approximately 24 hours, the dechlorinated and settled water was pumped through rapid sand filters, and mixed with well water to adjust the salinity to 2 parts per thousand (ppt). This water was recirculated through the rapid sand filters for an additional 12 hours before it was ready for use in the culture units. The filter back-flushing procedure, depending on the size of the rearing unit, exchanged between one-fifth and one-fourth the total volume of each intensive culture system each day. In order to further improve water quality, approximately 66% of the volume of each rearing system was changed each week.

Water chemistry was monitored prior to arrival of striped bass fry and once each week during the rearing season. Parameters checked included pH, nitrate nitrogen, nitrite nitrogen, and total ammonia. The Water Chemistry Lab at GCRL performed the water analysis following Standard Methods procedures (Figure 1). Dissolved oxygen (DO) , temperature, and salinity were checked daily. A Yellow Springs Instruments Company (YSI) Model 55 (TM) oxygen analyzer was used to determine DO. A YSI, Model 33 (TM) was used to check salinity, and temperature (Figure 2).

Approximately five hundred forty-five thousand (545,000) striped bass fry in ten live fish shipping boxes were obtained from the Marion Fish Hatchery in Marion, Alabama. The acclimation process was initiated by placing the sealed shipping bags in the rearing units into which the fry were to be distributed. The bags were opened and the outer bag removed. The dissolved oxygen (DO) and the temperature of the water in the inner bags was checked. The readings were compared to those of the rearing systems, and the acclimation process started. Water was slowly poured into the bags containing the fry until the initial volume was doubled. Temperature of the water was monitored while the fish were acclimating and the regime adjusted to allow the fry time to gradually acclimate to physical and chemical parameters of the intensive culture systems. The tempering process lasted approximately 45 minutes. After the striped bass were acclimated, they were distributed throughout the tanks comprising the rearing systems. The fry were stocked at a density of approximately 4 fish per liter of water. *Artemia* sp. nauplii were offered to the fish after they were 96 hours old. Initially decapsulated brine shrimp nauplii were the principal food. When the fish were seven days old and their swim bladders were inflated, fatty acid enhanced brine shrimp were offered as food. Live food feeders were used to dispense the food. The automatic feeders discharged live food every 2.5 minutes.

An experiment conducted in 1989 to ascertain the feasibility of fatty acid enhancement of brine shrimp nauplii proved successful, and all brine shrimp nauplii used since then have been enhanced. The supplement, an enrichment media derived from the "Manual on Red Drum Aquaculture" (Chamberlain, et al, 1987), was prepared at GCRL. It consisted of an oil emulsion containing : 1) seawater, 2) menhaden oil, 3) raw chicken egg yolk, 4) tocopherol (vitamin E), and 5) AIN vitamin mixture 76. Twenty-eight milliliters of the emulsion were added to the brine shrimp hatching containers eight to twelve hours prior the scheduled harvest of nauplii. The shrimp were harvested, rinsed, and distributed to all 40 live-food feeders. The enhanced shrimp nauplii were used as food after day seven.

For several years uninflated swim bladders have been a major source of direct and/or indirect mortality. Striped bass are physostomous, which means they must have access to surface air to inflate their swim bladders. An oily film on the surface of the rearing tanks could inhibit obtaining surface air. One of the primary components of the enrichment media, menhaden oil, could contribute to the oil film. By not feeding the enhanced brine shrimp until after the striped bass had inflated their swim bladders eliminated the oil film, which allowed them access to surface air.

**Results and Discussion**

Survival rate experienced in phase I culture was better than that experienced in 1996 phase I culture (Table I). The 545,000 fry were from two females designated numbers 00066 and 00092. The fish were collected from Lewis Smith Lake and the Coosa River. Male number 5922 from Lewis Smith and male number 00026 from the Coosa were used to fertilize the respective eggs. The fry from the two brood fish were segregated in order to track their performance during intensive culture. Two hundred seventy-five thousand (275,000) fry were obtained from female #00092 and male 00026. These Atlantic race fry were stocked in systems B,D,F, G,and I. The average number stocked per raceway was 55,000 fish. Two hundred seventy thousand (270,000) fry were from female #00066 and male #5922 . These Gulf race fish were stocked in systems A,C,E,G & H at a density of 54,000 per tank.

The survival rate for both races for phase I culture averaged 35%. Fish harvested from G-system were not included in the percent survival since fry from both females were used to stock the system. The phase I survival rate for this system was 13%. Gulf race striped bass averaged 1 g wet weight, and 46 mm TL. The Atlantic race fish also averaged 1 g wet weight, and 49 mm in TL.

There were no appreciable differences in the culture parameters for the nine culture systems . The first major mortalities of the rearing season began occurring 5/10/97 (25 days post-hatch), and continued for the next four days. Numerous dead and dying fish were observed on the bottom of the rearing tanks and in the water column. However, the mortalities were not as protracted or as wide spread as they were in 1996.

A review of water chemistry revealed that ammonium nitrogen averaged 0.13 ppm for the eleven week culture period. The pH for 75 days averaged 8.31. Nitrite nitrogen averaged 0.05 ppm for phase I culture (Figure 1). Nitrate nitrogen averaged 0.03 ppm. Dissolved oxygen averaged 8.1 ppm for the first 75 days of culture (Figure 2). The water temperature averaged 21.7 degrees Celsius, and the salinity averaged 1.9 ppt.

All phase II culture (181 days) was conducted in the intensive culture tanks at GCRL by Anadromous Fish Project personnel. This phase of the 1997 culture period also proved relatively uneventful and relatively successful. A prepared fish food diet was started during phase I culture 5/22/97 (fish were 45 days old). The fish remained on the prepared food for the duration of phase I and phase II culture. The particle size and quantity of the food was increased as the demand increased.

Phase II culture ended November 5, 1997. The water level in individual systems was lowered, and the fish were netted. Aliquot of 25 fish were taken from each system and individual lengths and weights were determined. The average size fish per system ranged from 31.2 g and 141.1 mm in F-system to 85.0 g and 188.1 mm in E- system. The average weight of the phase II fingerlings was 52.4 g and the average length was 163.3 mm (Table I). Overall survival for phase II culture was 59.68%. The Gulf fish averaged 63.2 g wet weight and 172.7 mm total length. The phase II

Atlantic fish averaged 41.5 g and 153.8 mm. Survival of Atlantics averaged 58.4%, while survival of Gulfs averaged 46%. Four thousand seven hundred thirty-four (4,734) Gulf fish were tagged, compared to 7,191 Atlantic striped bass. The 2,890 fish harvested from G-system were both Atlantic and Gulf race, and they were not included in the figures for either race (Table I).

All healthy phase II fingerlings were then tagged. The tagging procedure consisted of anesthetizing the fish and inserting a t-bar tag into the upper left dorsal side of the fish just below the first dorsal fIN (Figure 4). After each fish was tagged, it was placed in a discharge pipe that emptied directly into the transport tank. This procedure alleviated the handling of the fish after they were tagged. The fish were transported to the stocking sites (Figure 8). A total of 14,804 tagged phase II striped bass fingerlings were released in coastal tributaries (Table II). Four thousand five hundred sixty-seven (4,567) of the total were stocked into the Pascagoula River System. One thousand six hundred eighty-eight (1,688) were Gulf race striped bass, and 2,879 were Atlantics.

Throughout phase II culture, the DO never dropped below 4.5 ppm, and averaged 7.2 ppm. The water temperature remained in the 13.4 to 29.3°C range, and averaged 24.3°C. The salinity averaged 2.1 ppt, and ranged from 1.0 to 4.3 ppt (Figure 3).

During 1996 phase II culture four thousand five hundred seventy-six (4,576) died as a direct or indirect result of having an uninflated swim bladder. This figure represented 23% of the 20,177 phase II fish initially stocked. At the end of phase II culture, 3,358 fish with uninflated swim bladders were removed from the culture tanks and discarded. If these fish had inflated swim bladders and could have been included in total survival for phase II culture, 76.11% of the 20,177 fingerlings would have been tagged and released.

A concerted effort was undertaken in 1997 to eliminate the uninflated swim bladder malady. Since striped bass must obtain air at the surface of the water to inflate their swim bladder by day seven post hatch, care was taken to insure the water/air interface was free from oil and the surface water was well agitated. This was accomplished by withholding the menhaden oil rich brine shrimp enrichment media until the swim bladder had been inflated. Additionally, water from the recirculating pumps was sprayed vigorously across the surface of each raceway to help aerate the water and to help prevent the formation of an oily film. With these two changes, uninflated swim bladders were a non-factor in 1997.

To obtain the cooperation of fishermen capturing striped bass, an extensive public awareness program was conducted. News releases explaining the goals and objectives of the striped bass restoration program were given to local newspapers and magazines. Posters were placed around boat launching ramps, in and around fishing camps, and in sporting goods stores. Fishermen and fish-camp operators were interviewed, and most of them proved very cooperative; however, much more work remains to be done in this regard. A large percentage of the fishermen that were interviewed reported seeing or knowing of other fishermen who caught striped bass but were not reporting their catch.

Analysis of Mississippi coast wide tag return data has revealed some interesting facts resulting from those anglers that did report their catch. One hundred twelve (112) tagged striped bass were reported in 1997-1998 project year (Table III). They averaged 531 days from the date of release to the date of capture. The fish moved an average of 22.2 km from the release site to the capture site. The fish averaged 1,540.3 grams in weight and 374.4 mm in length. The average rate of growth calculated from these data was 1.9 gm and 0.4 mm per day. A majority of the tagged fish reported during the project year were in their second year. The average coefficient of condition for these fish was 0.16. The largest tagged striped bass reported weighed 8.17 kg and was 88.2 cm in total length. The fish was caught 3,641 days (9.98 years) after it was stocked.

Project personnel recorded 35 tag returns from the Pascagoula River System for the July 1, 1997 through June 30, 1998 project year. These fish averaged 425 days from release to capture (Figure 6). The striped bass traveled an average 18 km from the release site to point of capture (Figure 7). The average total length for the 35 fish was 335 mm (Figure 8). The longest period time from stocking to capture was 3,641 days (9.98 years) (Table III, Figure 6). The maximum distance between stocking site and capture was 42 km (Figure 7). The largest fish reported during this project was 7.72 kg and 88.2 cm. Twenty-seven (27) of the 35 fish reported from the Pascagoula River System were released at Old Oak Marina. Eight (8) of remaining nine fish were stocked into Bluff Creek at Dee's Landing (Figure 5).

Analysis of tag return data from previous projects revealed that fish >45 grams in size at stocking resulted in the greatest number of tag returns. Also, fish stocked in late fall provided a greater percentage of tag returns than those stocked in summer or early fall. Several plausible explanations can be offered: 1) predators may be less active in late fall and early winter; 2) striped bass released later in the year may be larger in size and better able to escape predation; and 3) the fish are in better physical condition in the cool water months which could enhance their chances of survival.

The majority (56) of the tagged striped bass reported to project personnel were caught in the Biloxi River System, followed by the Pascagoula River System (35), and the Pearl River System (14). The remaining fish came from other areas like Lake Pontchartrain and the Rigolets in Louisiana. These data reflect both the stocking emphasis and the fishing pressure on these systems for the past several years. Prior to 1989 approximately 70% of the striped bass released by GCRL were released in the Biloxi River System, and another 20% were stocked in the Pascagoula River System. The remaining fish were distributed among the other coastal tributaries.

Beginning in 1989 the stocking emphasis was changed in order to concentrate the restoration efforts on the two major river systems of coastal Mississippi, the Pascagoula and the Pearl. In 1996 striped bass were again stocked in Biloxi River System. The number of tag returns from these systems reflects the change in the stocking effort (Table III). Four tagged fish reported during the 1997-1998 project year came from Louisiana waters. This was an additional change resulting from releasing striped bass in the East Pearl River, which serves as the western boundary of the state.

In 1989 eighty phase II striped bass fingerlings were placed in raceways at GCRL to be maintained for future brood stock. They were selected for their rapid rate of growth and vigor. The fish were initially stocked into two recirculating tanks each with a capacity of approximately 1,890 liters of water. At the initiation of brood stock culture they averaged 1.6 g in weight and 48.22 mm in length. On April 23, 1990 the fish averaged 531 g in weight and 297 mm in length. Presently, the fish average more than 8 kg and are healthy and growing.

In the fall of 1993, 200 hundred phase II Gulf race striped bass were placed in fiberglass raceways (1.83 m x 4.57 m x 0.91 m) located in the Anadromous Building at GCRL. These fish will continue to be reared as future brood fish. The fish will enter their fifth year in 1998. By 1999 they will be sexually mature and can be used to produce Gulf race fry.

Electro-fishing equipment belonging to GCRL was employed throughout the spring of 1997 and the fall of 1998 in a continuing effort to locate spawnable fish. Hopefully, a cooperative effort can be developed between GCRL, the Mississippi Department of Wildlife, Fisheries, and Parks, and Mississippi State University which will significantly enhance the striped bass restoration program. The ground work for such a cooperative effort has been put in place. The results of this cooperation should be evident in the near future.

**Conclusions**

No significant differences were seen for the two races during phase I intensive culture. The survival rate for both averaged 35%. Growth rates were very similar with the Gulf race striped bass averaging 1 g in weight and 46 mm in total length, and the Atlantic race also averaging 1 g in weight and 49 mm.

There were no appreciable differences in the culture parameters for the nine culture systems during phase I culture. Any changes in water quality occurred throughout the culture system, and was not identified with any one culture unit.

Phase II culture was very similar to the first culture period in that no significant differences in culture parameters were observed. Unlike phase I culture, differences in survival and growth were obvious between the two races. The survival rate for the Gulf fish was 46%, and 58% for the Atlantics. Growth for the Gulf fish was 63.2 g and 163.3 mm and 41.5 g and 153.8 mm for the Atlantic race.

No obvious correlations can be made for the difference in survival between the two races. However, inverse relationship is very apparent between survival and growth. The Gulf race fish experienced the poorer survival and averaged a much more impressive growth rate, while the Atlantic fish had a much better survival rate and a much smaller average size. The more numerous Atlantic fish experienced greater competition for food than the less numerous Gulf striped bass.

Tag returns for the July 1,1997 through June 30, 1998 project year were low, with only 35 tagged striped bass reported. The average number of days from stocking to capture was 425 (1.16 years) (Figure 10). The reported fish moved an average of 18 km from the stocking site to the capture location. The fish averaged 335 mm in total length. The largest tagged fish reported weighed 7.72 kg and was 88.2 cm in total length.

Tag return data for the two races released in 1997 is preliminary, since the fish will not seriously impact the fishery until the fall of 1998, and the spring of 1999. Eleven tag returns have been reported for the 1997 year class released in the Pascagoula River System. Six of the striped bass were Atlantic race and five were Gulfs. Atlantic race fish averaged 176 mm in total length, and the Gulf fish averaged 240 mm. The Gulf fish were caught an average of 16 km from the stocking site, and the Atlantic race striped bass were caught 12 km from the stocking site.

No significant inferences can be made from the rearing or tag return data as to the enhanced physiological suitability of these two races of striped bass to the coastal tributaries of Mississippi. This study does indicate that further evaluations will be necessary.

## Table I: Phase I culture data

Gulf Coast Research Laboratory Striped Bass Project

07-Apr-97 FISH ARRIVED 17:20 gulf striped bass from Smith Lake female 00066 (LSC 66) male 5922 (LSC 65)
estimated 270,000 larvae. Gulf race stocked into A C E G & H.

Atlantic striped bass from Coosa River female 00092 (LSC 57) male 00026 (LSC 58)
estimated 275,000 larvae. Atlantic race stocked into B D F G & I.

1997 Phase I harvesting

BILOXI BAY SYSTEM

| System and Race | number stocked | number harvested | weight kg harvested | percent survival | restocked for Phase II | released | Pascagoula R. Old Oak | Pearl R. Curtis Johnson | Tchouticabouffa R. Lil Joe's | Fort Bayou Washington Ave. | Biloxi R. Popps' Ferry | Ft. Bayou Bristol St | Date Released |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A (GULF) | 54000 | 21196 | 21 | 39 | 2715 | 18482 | | 18482 | | | | | 27-Jun-97 |
| B (ATLANTIC) | 55000 | 22299 | 26 | 41 | 2675 | 19624 | | 19624 | | | | | 27-Jun-97 |
| C (GULF) | 54000 | 18223 | 22 | 34 | 2608 | 15616 | | | 15616 | | | | 30-Jun-97 |
| D (ATLANTIC) | 55000 | 16045 | 27 | 29 | 3557 | 12488 | | | 12488 | | | | 30-Jun-97 |
| E (GULF) | 54000 | 22079 | 22 | 41 | 2577 | 19502 | | | | | | 19502 | 01-Jul-97 |
| F (ATLANTIC) | 55000 | 22171 | 23 | 40 | 2471 | 19700 | | | | 19700 | | | 24-Jun-97 |
| G (BOTH) | 109000 | 14329 | 24 | 13 | 4584 | 9744 | 9744 | | | | | | 25-Jun-97 |
| H (GULF) | 54000 | 13996 | 20 | 26 | 2433 | 11563 | | | | | 11563 | | 26-Jun-97 |
| I (ATLANTIC) | 55000 | 16933 | 21 | 31 | 2384 | 14549 | | | | | 14549 | | 26-Jun-97 |
| totals | 545000 | 167271 | 205 | 31 | 26004 | 141267 | 9744 | 38106 | 28104 | 19700 | 26112 | 19502 | |

1997 Phase I Culture 7 Apr 97 - 24 Jun 97

| genotype | system | avg wt (gm) | avg lt (mm) | % survival | overall avg wt | overall avg l | avg survival |
|---|---|---|---|---|---|---|---|
| GULF | A | 1 | 44 | 39 | | | |
| GULF | C | 1 | 48 | 34 | | | |
| GULF | E | 1 | 43 | 41 | | | |
| GULF | H | 1 | 48 | 26 | 1 | 46 | 35 |
| ATLANTIC | B | 1 | 49 | 41 | | | |
| ATLANTIC | D | 2 | 54 | 29 | | | |
| ATLANTIC | F | 1 | 47 | 40 | | | |
| ATLANTIC | I | 1 | 48 | 31 | 1 | 49 | 35 |
| BOTH | G | 2 | 52 | 26 | | | |

## **Table II:** Phase II culture data

Gulf Coast Research Laboratory Striped bass project
1997 Phase II harvesting

| System and Race | number stocked | number harvested | weight kg harvested | percent survival | restocked | released | Pascagoula R. Old Oak | Pearl R. Curtis Johnson | BILOXI BAY SYSTEM | | | Date Released |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Tchouticabouffa R. Lil Joe's | Fort Bayou Washington Ave. | Ft. Bayou Bristol St | |
| A (GULF) | 2715 | 1439 | 83 | 53.0 | 11 | 1428 | | 1428 | | | | 14-Nov-97 |
| B (ATLANTIC) | 2675 | 1359 | 76.6 | 50.8 | 0 | 1359 | | | | | 1359 | 13-Nov-97 |
| C (GULF) | 2608 | 1281 | 93 | 49.1 | 0 | 1281 | 1281 | | | | | 11-Nov-97 |
| D (ATLANTIC) | 2375 | 1323 | 70.3 | 55.7 | 0 | 1323 | | | 1323 | | | 12-Nov-97 |
| E (GULF) | 2577 | 407 | 41 | 15.8 | 0 | 407 | 407 | | | | | 11-Nov-97 |
| F (ATLANTIC) | 2471 | 2879 | 93.5 | 116.5 | 0 | 2879 | 2879 | | | | | 10-Nov-97 |
| G (BOTH) | 4584 | 2890 | 158 | 63.0 | 0 | 2890 | | 2890 | | | | 05-Nov-97 |
| H (GULF) | 2433 | 1607 | 90.9 | 66.0 | 0 | 1607 | | | 1607 | | | 06-Nov-97 |
| I (ATLANTIC) | 2384 | 1630 | 71 | 68.4 | 0 | 1630 | | | | 1630 | | 07-Nov-97 |
| totals | 24822 | 14815 | 777.9 | 59.7 | 11* | 14804 | 4567 | 4318 | 2930 | 1630 | 1359 | |

* Restocked to the Marine Education Center

1997 Phase II Culture 24 Jun 97 - 5-Nov 97 181 DAYS IN CULTURE SYSTEM

| genotype | system | avg wt (gm) | avg lt (mm) | % survival | overall avg wt | overall avg lt | avg survival |
|---|---|---|---|---|---|---|---|
| GULF | A | 54.9 | 168.0 | 53 | | | |
| GULF | C | 64.4 | 174.7 | 49.1 | | | |
| GULF | E | 85.0 | 188.1 | 15.8 | | | |
| GULF | H | 48.3 | 160.0 | 68.4 | 63.2 | 172.7 | 46.6 |
| ATLANTIC | B | 49.1 | 163.3 | 50.8 | | | |
| ATLANTIC | D | 46.0 | 158.2 | 55.7 | | | |
| ATLANTIC | F | 31.2 | 141.4 | 116.5 | | | |
| ATLANTIC | I | 39.5 | 152.2 | 66 | 41.5 | 153.8 | 72.3 |
| BOTH | G | 50.9 | 160.8 | | | | |

**Table III:** Tag return data - 1 July 1997 - 30 June 1998

| | TAG NO. | TAG CODE | RELEASE LOCATION | RELEASE DATE | CAPTURE LOCATION | CAPTURE DATE | DAYS FROM RELEASE | MOVEMENT KM | WEIGHT GM | LENGTH MM | GROWTH PER DAY WEIGHT | GROWTH PER DAY LENGTH | YEAR CLASS | COEFFICIENT OF CONDITION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GULF | NS0889 | D/O | O.O. | 11-Nov-97 | ESC | 28-Jun-98 | 229 | 41.8 | | 286 | | 0.5 | 1.1 | |
| | NT0782 | D/O | O.O. | 11-Nov-97 | PAS. | 28-Mar-98 | 137 | 11 | | 152 | | -0.2 | 0.9 | |
| | NE967 | D/O | O.O. | 11-Nov-97 | PAS. | 09-Mar-98 | 118 | 6.9 | | 426 | | 2.1 | 0.8 | |
| | NT0782 | D/O | O.O. | 11-Nov-97 | PAS. | 28-Mar-98 | 137 | 11 | | 152 | | -0.2 | 0.9 | |
| | NE967 | D/O | O.O. | 11-Nov-97 | PAS. | 09-Mar-98 | 118 | 6.9 | | 426 | | 2.1 | 0.8 | |
| ATLANTIC | NT0136 | D/O | O.O. | 10-Nov-97 | BLUFF CR. | 27-Feb-98 | 109 | 7.8 | | 178 | | 0.3 | 0.8 | |
| | NR0332 | D/O | O.O. | 10-Nov-97 | PAS. | 03-Mar-98 | 113 | 14.4 | | 174 | | 0.3 | 0.8 | |
| | NT0136 | D/O | O.O. | 10-Nov-97 | BLUFF CR. | 27-Feb-98 | 109 | 7.8 | | 178 | | 0.3 | 0.8 | |
| | NR0063 | D/O | O.O. | 10-Nov-97 | PAS | 25-Nov-97 | 15 | 17.8 | | | | | 0.6 | |
| | NR0332 | D/O | O.O. | 10-Nov-97 | PAS. | 03-Mar-98 | 113 | 14.4 | | 174 | | 0.3 | 0.8 | |
| | NR0336 | D/O | O.O. | 10-Nov-97 | PAS | 14-Jul-98 | 246 | 7.8 | | 356 | | 0.8 | 1.2 | |
| ATLANTIC | JW0811 | D/O | BLUFF CR. | 15-Nov-96 | P.P. | 23-Sep-97 | 312 | 31.3 | | | | | 1.4 | |
| | NJ0463 | D/O | BLUFF CR. | 15-Nov-96 | PAS. | 09-May-98 | 540 | 24.3 | | 305 | | 0.2 | 2.1 | |
| | NK0130 | D/O | BLUFF CR. | 15-Nov-96 | P.P. | 12-Aug-97 | 270 | 31.3 | | 319 | | 0.5 | 1.3 | |
| | NJ0493 | D/O | BLUFF CR. | 15-Nov-96 | PAS. | 10-Nov-97 | 360 | 27.3 | | 343 | | 0.5 | 1.6 | |
| | NJ0463 | D/O | BLUFF CR. | 15-Nov-96 | PAS. | 09-May-98 | 540 | 24.3 | | 305 | | 0.2 | 2.1 | |
| | MJ277 | D/O | BLUFF CR. | 15-Nov-96 | B.CR. | 06-Sep-97 | 1026 | 33.5 | 1930 | 539 | 1.8 | 0.4 | 3.4 | 0.12 |
| | NK0477 | D/O | BLUFF CR. | 15-Nov-96 | P.P. | 11-Aug-97 | 269 | 31.3 | | 257 | | 0.3 | 1.3 | |
| | NK0206 | D/O | BLUFF CR. | 15-Nov-96 | P.P. | 16-Aug-97 | 274 | 31.3 | | 294 | | 0.4 | 1.3 | |
| ATLANTIC | NF676 | D/O | O.O. | 11-Nov-96 | P.P. | 24-Aug-97 | 286 | 21 | | 490 | | 1.1 | 1.4 | |
| | NF780 | D/O | O.O. | 11-Nov-96 | PAS. | 04-Apr-98 | 509 | 6.9 | | 464 | | 0.5 | 2.0 | |
| | NF304 | D/O | O.O. | 11-Nov-96 | P.P. | 07-Nov-97 | 361 | 20.4 | | 330 | | 0.4 | 1.6 | |
| | NF561 | D/O | O.O. | 11-Nov-96 | P.P. | 29-Aug-97 | 291 | 20.4 | | | | | 1.4 | |
| | NF780 | D/O | O.O. | 11-Nov-96 | PAS. | 04-Apr-98 | 509 | 6.9 | | 464 | | 0.5 | 2.0 | |
| | NF459 | D/O | O.O. | 11-Nov-96 | P.P. | 28-Oct-97 | 351 | 20.4 | | | | | 1.5 | |
| | NF561 | D/O | O.O. | 11-Nov-96 | BIL | 24-Sep-97 | 317 | 20.4 | | 305 | | 0.4 | 1.4 | |
| | NF381 | D/O | O.O. | 11-Nov-96 | P.P. | 11-Sep-97 | 304 | 20.4 | | | | | 1.4 | |
| MIXED | NA364 | D/O | O.O. | 05-Nov-96 | P.P. | 13-Aug-97 | 280 | 20.4 | | 294 | | 0.5 | 1.3 | |
| | MZ281 | D/O | O.O. | 05-Nov-96 | P.P. | 29-Aug-97 | 297 | 20.4 | | | | | 1.4 | |
| | MY786 | D/O | O.O. | 05-Nov-96 | P.P. | 16-Aug-97 | 284 | 20.4 | | 270 | | 0.4 | 1.3 | |
| | MZ630 | D/O | O.O. | 05-Nov-96 | P.P. | 22-Nov-97 | 382 | 20.4 | | 356 | | 0.5 | 1.6 | |
| | MZ326 | D/O | O.O. | 05-Nov-96 | PAS. | 14-Nov-97 | 374 | 17.5 | | | | | 1.6 | |
| ATLANTIC | MW231 | D/O | O.O. | 15-Nov-95 | PAS. | 19-Feb-98 | 827 | 0.1 | | | | | 2.8 | |
| | MW231 | D/O | O.O. | 15-Nov-95 | PAS. | 19-Feb-98 | 827 | 0.1 | | | | | 2.8 | |
| | LI866 | D/O | ESC | 17-Nov-87 | P.P. | 05-Nov-97 | 3641 | 2.7 | 7718 | 882 | 2.1 | 0.2 | 10.5 | 0.11 |

| | DAYS FROM RELEASE | MOVEMENT KM | WEIGHT GM | LENGTH MM | GROWTH PER DAY WEIGHT | GROWTH PER DAY LENGTH | YEAR CLASS | COEFFICIENT OF CONDITION |
|---|---|---|---|---|---|---|---|---|
| MIMIMUM | 15 | 0 | 1930 | 152 | 1.8 | -0.2 | 0.6 | 0.11 |
| AVERAGE | 425 | 18 | 4824 | 335 | 2.0 | 0.5 | 1.7 | 0.12 |
| MAXIMUM | 3641 | 42 | 7718 | 882 | 2.1 | 2.1 | 10.5 | 0.12 |
| STD DEV | 592.28 | 10 | 2894 | 152 | 0.1 | 0.5 | 1.6 | 0.01 |
| VARIANCE | 3.51E+005 | 1.01E+002 | 8.38E+006 | 2.32E+004 | 2.05E-002 | 2.71E-001 | 2.65E+000 | 2.90E-005 |
| RANGE | 3626 | 42 | 5788 | 730 | 0.29 | 2.29 | 9.96 | 0.01 |
| COUNT | 35 | 35 | 2 | 26 | 2.00 | 26.00 | 35.00 | 2.00 |

**Figure 1:** Water chemistry for phase I culture

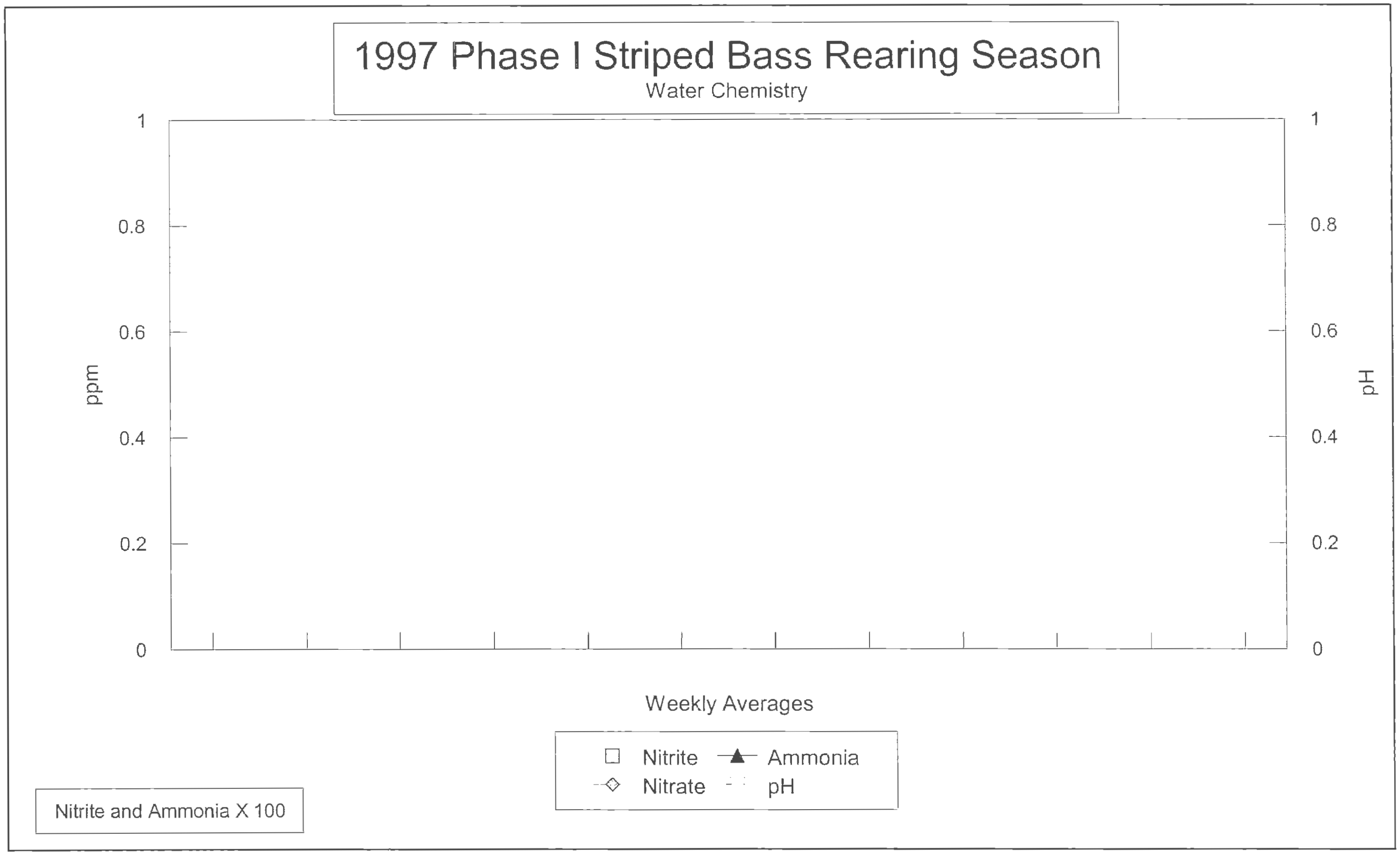


**Figure 2:** Water quality for phase I culture

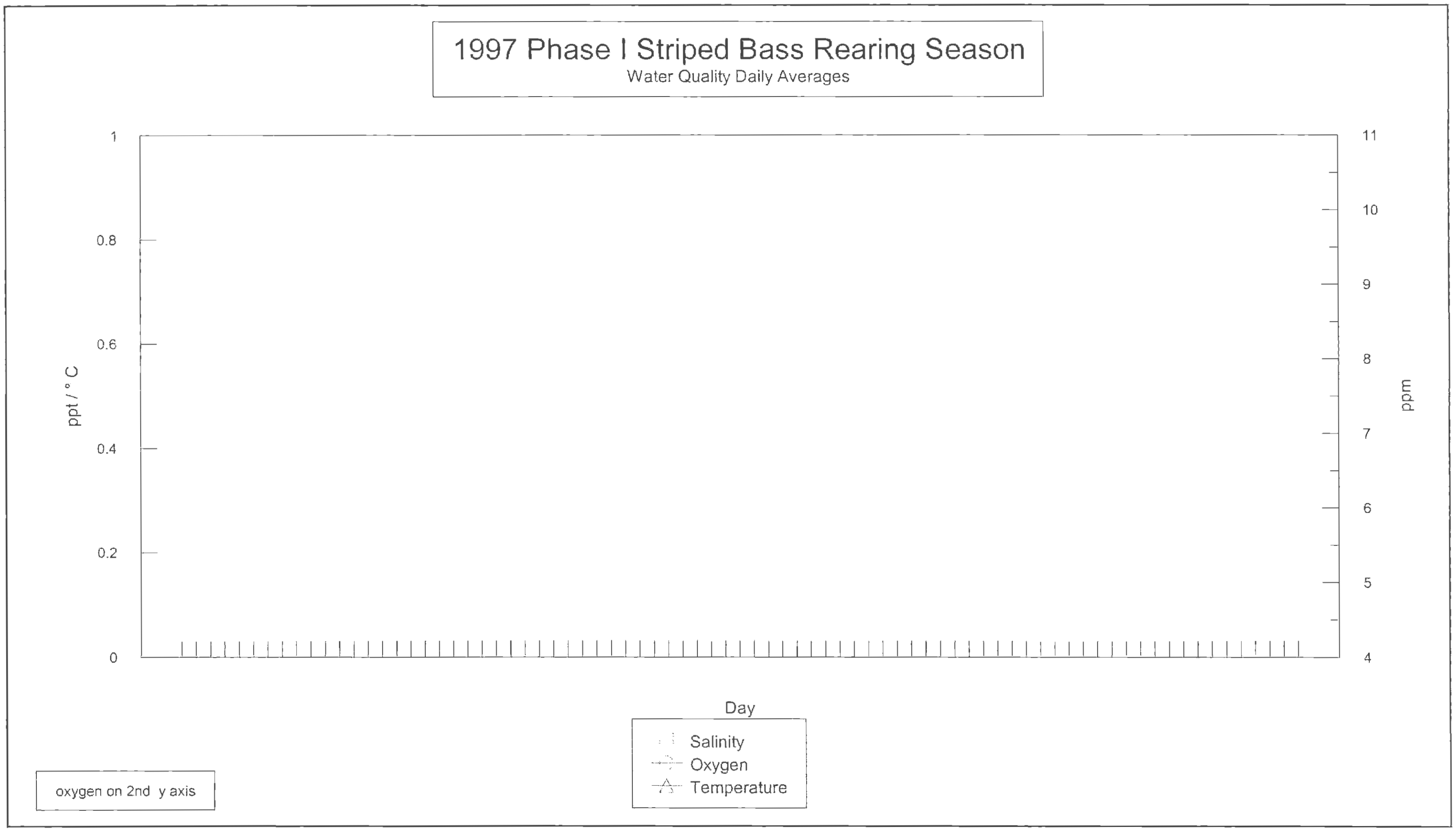


**Figure 3:** Water quality for phase II culture

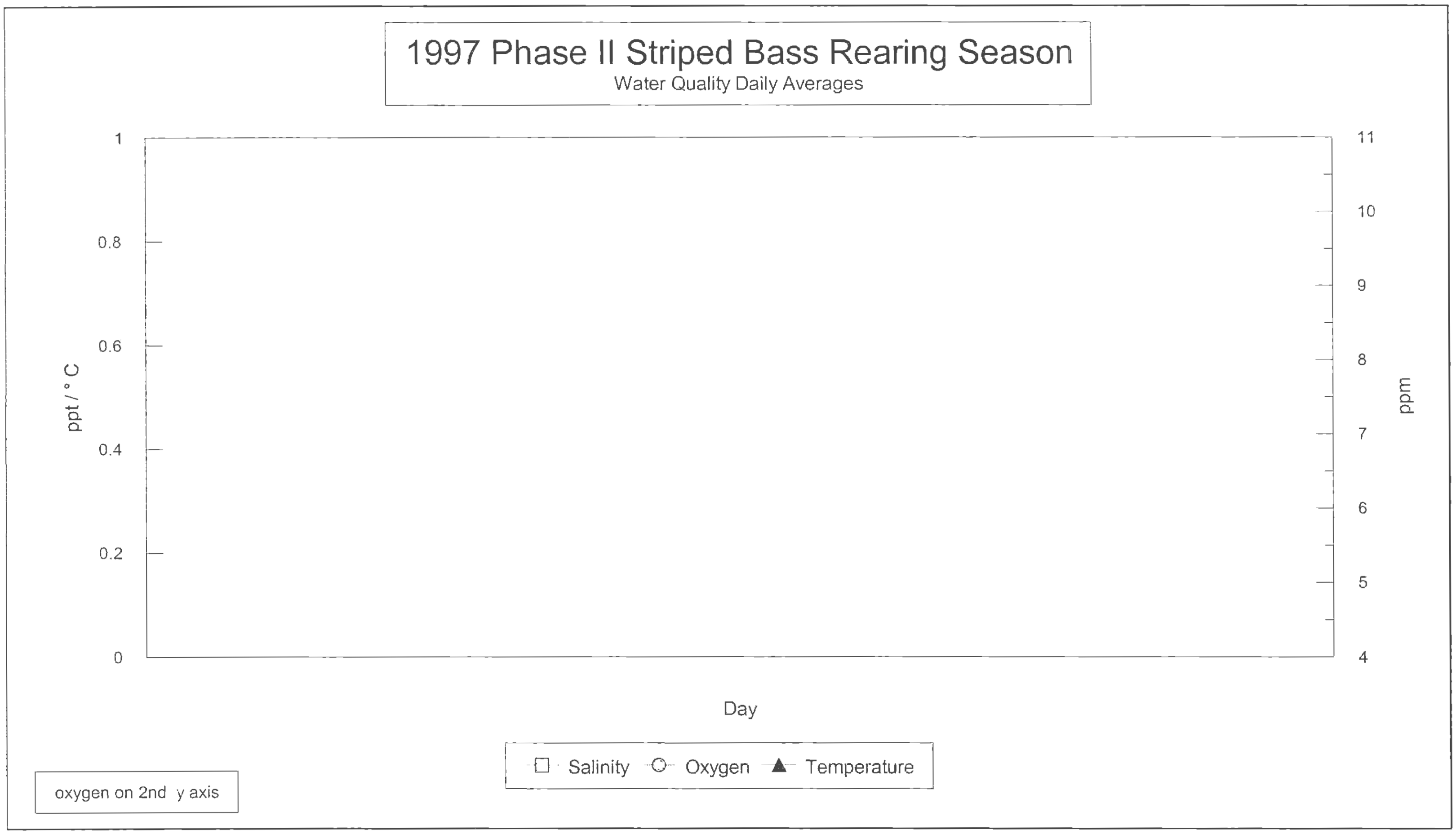


Figure 4: Diagram and location of T-bar tag.

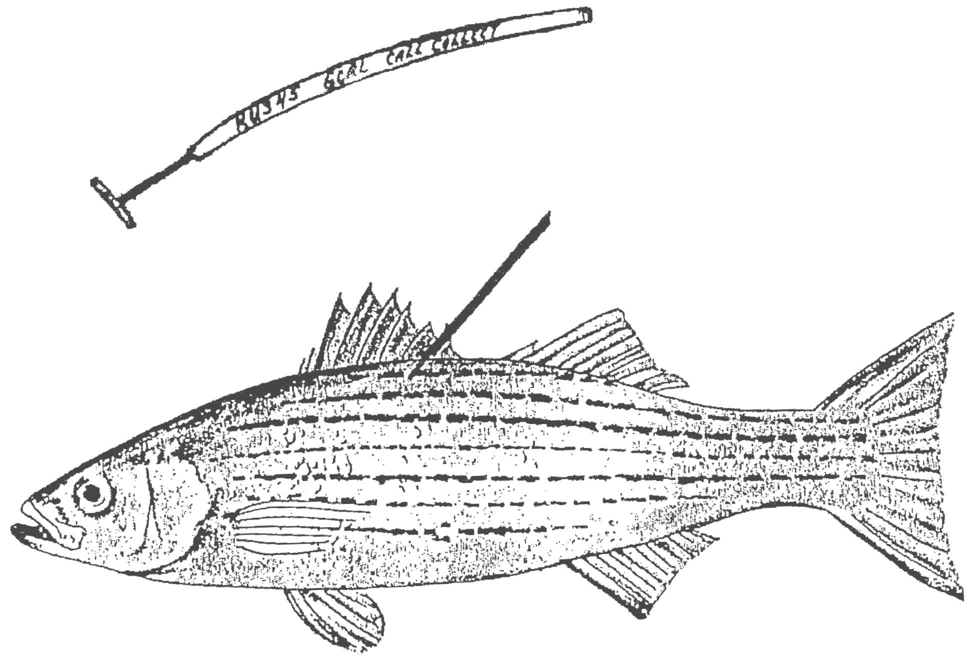


**Figure 5:** Pascagoula system stocking locations

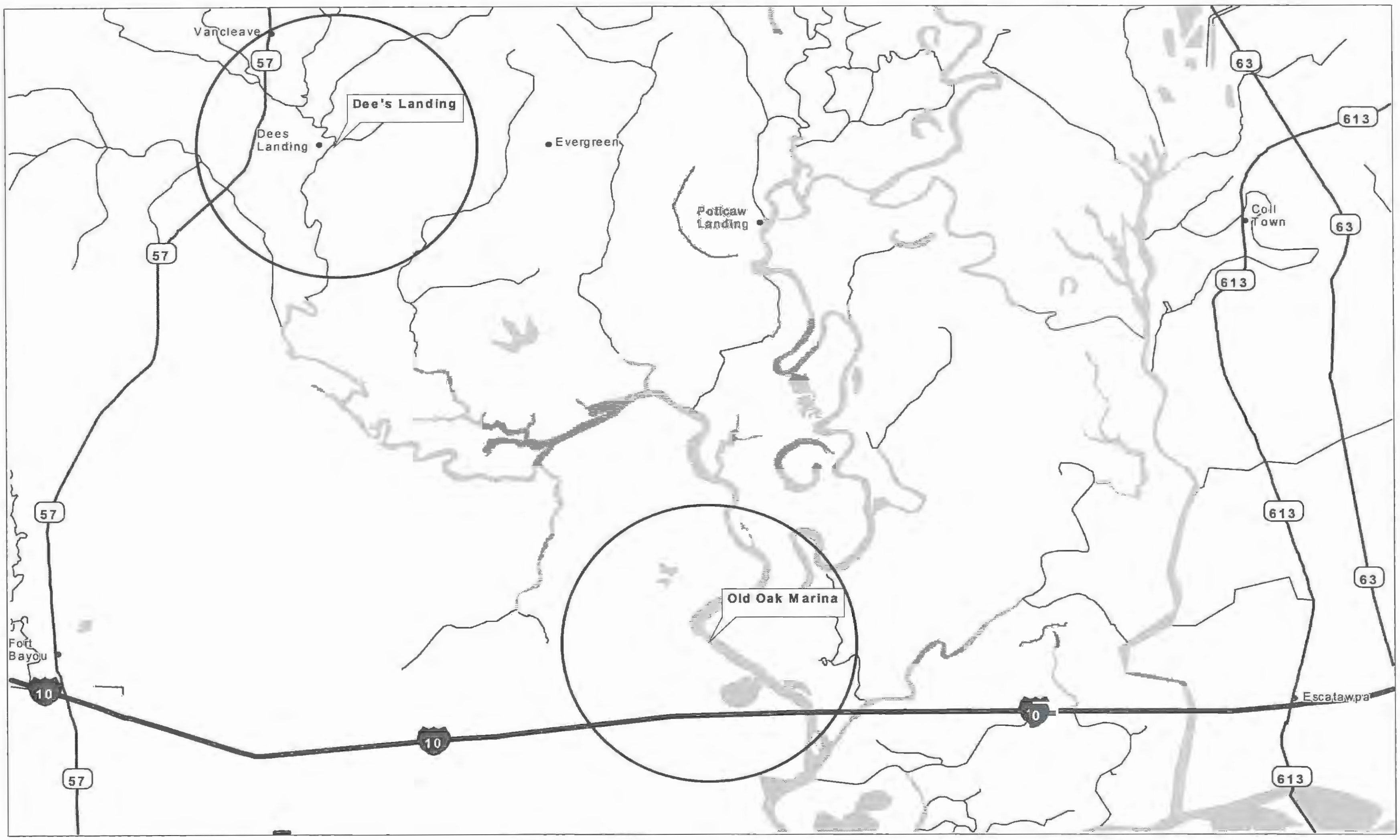


**Figure 6:** Tag return data for days from release

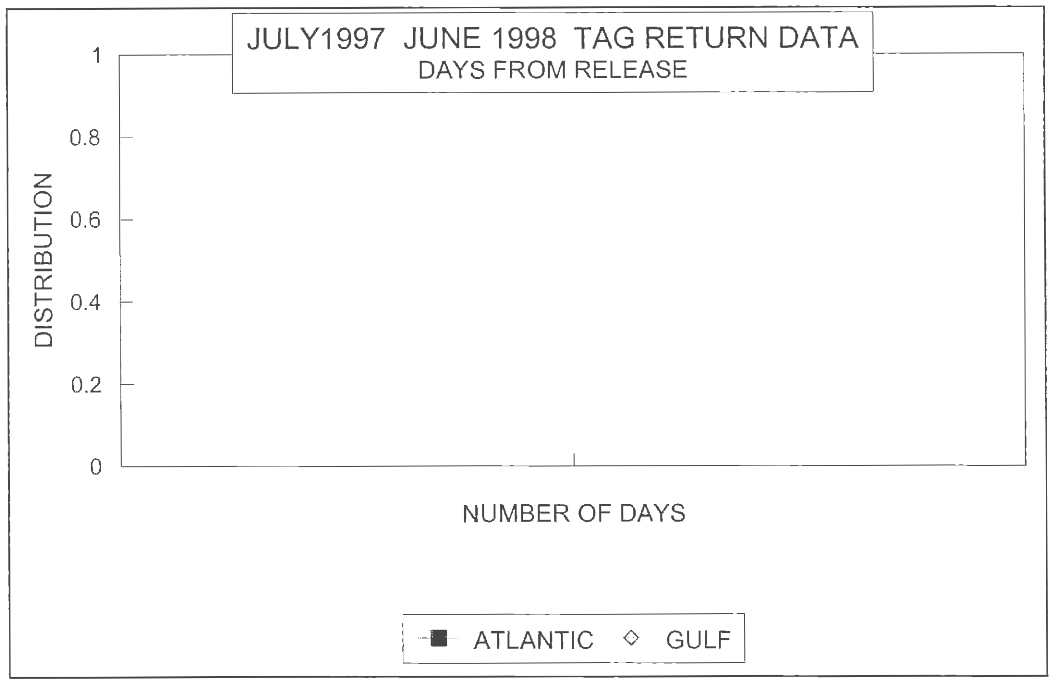


**Figure 7:** Tag return data for distance from release

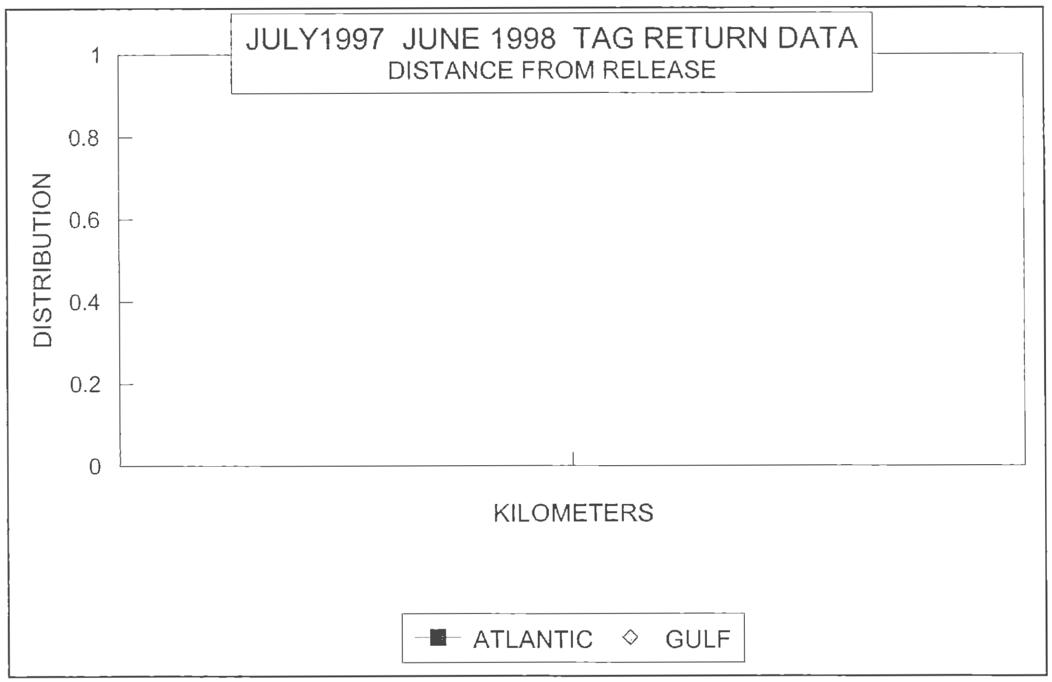


**Figure 8:** Tag return data for length

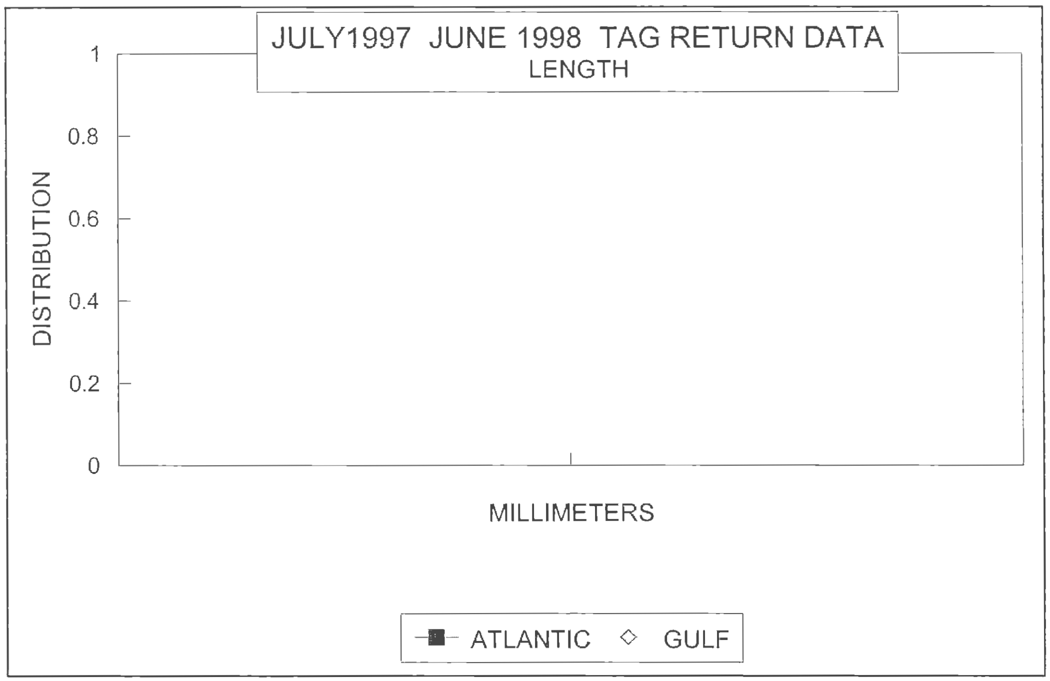


**Figure 9:** Tag return data for growth per day length

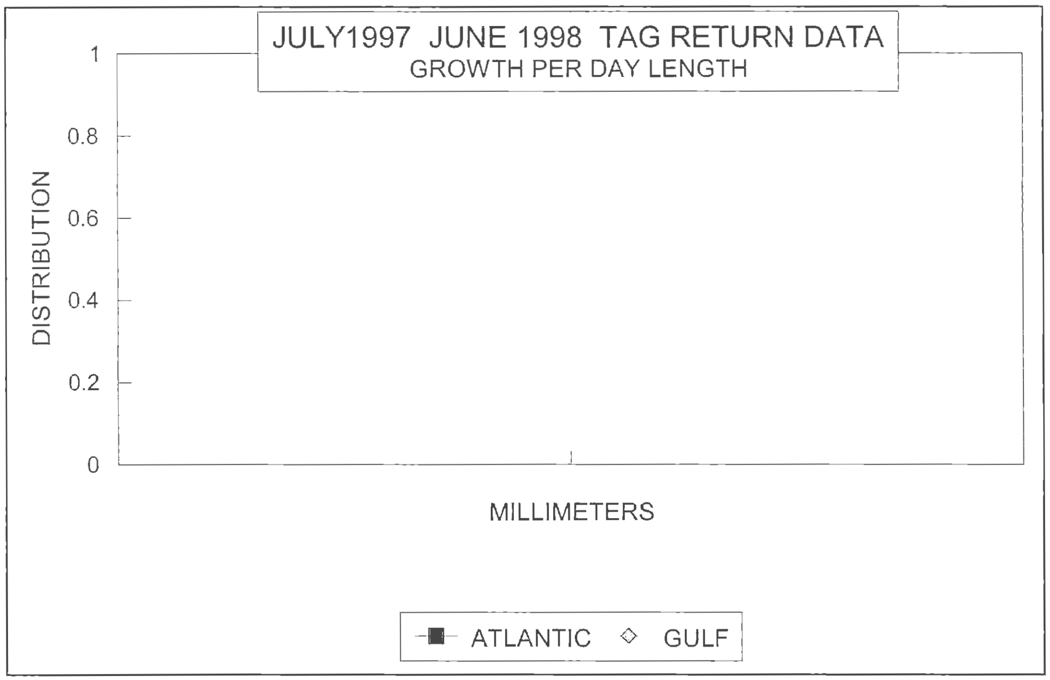
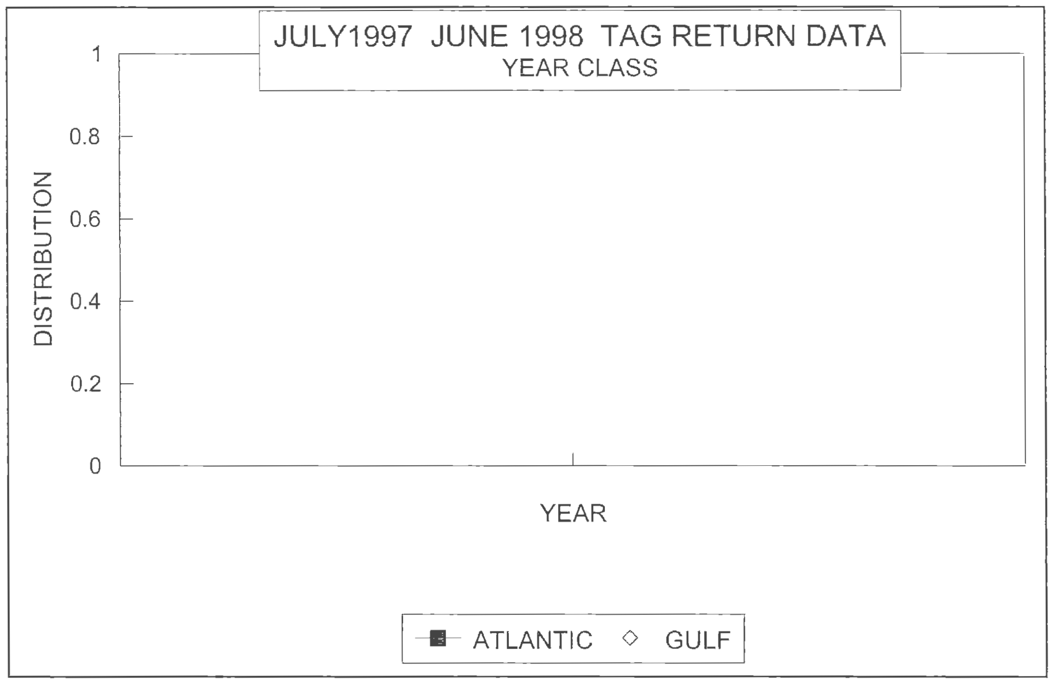


**Figure 10:** Tag return data for year class



## Perspectives of the Pascagoula River Striped Bass Fishery

*John Mareska, Mississippi State University*

### Activities Scheduled

Efforts will be made to capture between 10 and 20 adult striped bass during the late winter and early spring of 1998 utilizing gill nets and hoop nets. Gill nets will be checked every 1-2 hours based on catch rates to minimize the stress period for captured fish. Hoop nets will be checked every four hours, except for overnight sets. Radio transmitters will be obtained from Custom Telemetry, Watkinsville, Georgia, with a life expectancy of 2-3 years. Transmitter weight will be $<2\%$ of the fish weight. A directional loop antenna from Advanced Telemetry Systems will be used to locate transmitters in the field.

Surveys of physical habitat will be conducted during low stream flow and when temperatures in the streams are $\geq 27°C$, when striped bass typically seek out thermal refuge. Physical habitat surveys of Red and Black Creeks, and the Leaf and Chickasawhay Rivers will be conducted to locate spawning, thermal refuge, and other important habitat for striped bass. The areas surveyed for Red and Black Creeks extend from the Pascagoula River to I-59. The Leaf River will be surveyed to the confluence with the Bouie River, and the Chickasawhay River will be surveyed to the confluence with the Buckatunna River. Surveys of the Pascagoula River will be restricted to areas corresponding to locations of radio-tagged striped bass and during creel surveys. Attempts to locate radio-tagged striped bass via boat or airplane will be made at a minimum temporal resolution of biweekly (February-April) and weekly (May-October). Radio tracking will also coincide with each creel survey. During the creel survey, radio tracking will be of the reach addressed by the survey. Fish locations will be recorded using a GPS unit and habitat variables (i.e., water temperature, dissolved oxygen, and salinity) measured with an YSI instrument.

A creel survey will be conducted April-October during 1998. The survey will encompass the entire Pascagoula River from the I-10 bridge of both the east and west forks of the Pascagoula River up to the confluence of the Chickasawhay and Leaf Rivers. The river will be divided into 32-km stream reaches. Uniform spatial probabilities will be assigned to these stream reaches during the first year of the survey. Based on this uniformity of probabilities, six randomly determined sample dates per month will be selected. On each selected date, one of the 32-km stream reaches, and a six hour time period (morning or afternoon) will be randomly selected. Anglers encountered will be requested to participate in an interview. If an interview is granted by an angler, the angler will be classified by fish species targeted. The number of fish harvested by the angler will be recorded. All anglers will be questioned regarding their encounters with striped bass. Those anglers harvesting striped bass will be requested to have their fish weighed, length measured, and sample scales taken from the left side of the fish.

### Activities Accomplished

Prior to efforts directed toward collecting striped bass from the Pascagoula River system during late winter and early spring 1998, surgical techniques for implantation of radio transmitters were tested and refined using hybrid striped bass on the Mississippi State University campus. The techniques employed were highly successful and underscored our confidence regarding survival of wild-caught striped bass post surgery.

From 3 February to 30 April 1998 efforts to catch striped bass resulted in two striped bass caught and implanted with transmitters. Nine more striped bass, donated by the Gulf Coast Research Laboratory, were implanted with transmitters and released into Pascagoula River tributaries. One fish was released into Bluff Creek, and two fish each were released into the remaining tributaries (Red and Black Creeks; Chickasawhay and Leaf Rivers). Seven of the transmitters were relocated at a place different from their release location. Four radio-tagged striped bass have not been located since their release. Of the tagged fish that were located, four of the fish are known to have died. One of the deceased fish indicated movements downstream. The other three deceased fish all made movements upstream prior to their demise. The three remaining transmitters indicated movements downstream, but were subsequently lost. No radio-tagged fish, dead or alive, were located in areas considered as potential thermal refuges. Six days were spent flying over the river and its tributaries, including the Escatawpa River. Two transmitters were located utilizing the plane. All other contacts were made during habitat or creel surveys.

The physical habitat of the Pascagoula River was monitored during creel surveys and during efforts to locate radio-tagged fish. No thermal refuges were located in the main channel of the river. Water temperatures in the river (April-August) ranged from 27.7°C to 32°C. Dissolved oxygen ranged from 3.0 mg/L to 5.95 mg/L. Salinities ranged from 0.0 ppt (upstream) to 22.7 ppt (downstream). No salt water was detected upstream from the confluence of the east and west forks of the Pascagoula River. Of the two radio tagged fish, one moved up the Chickasawhay River before it was harvested and the other has not been located.

There are two potential locations for thermal refuge along the Pascagoula River. Big Cedar Creek (N 30°41.97 W 88° 37.94) in northern Jackson County is one. Water temperatures ranged from 21.4°C to 25.6°C. Salinities were consistently 0.0 ppt. Dissolved oxygen ranged from 5.29 mg/L to 5.95 mg/L. No striped bass were located in this creek. The other is Bluff Creek from the confluence with Mounger's Creek (N 30°31.74 W 88° 41.06) down to the confluence with Little Bluff Creek (N 30° 29.53 W 88° 41.09) in southern Jackson County. On 22 July, 1998, using an electrofisher boat, a mature striped bass was observed in this area. However, the radio-tagged fish released in this creek has not been located.

The Chickasawhay River up to the confluence with the Buckatunna River also did not yield thermal refuges for striped bass. However, small springs were found within the river channel. In Green County (N 31° 16' 44" W 88° 32' 20") a spring was located along a sand bar, but water depth was shallow (< 23 cm) and it cooled only a small area. Temperature was 19.8°C, salinity and DO were 0.0 ppt and 0.0 mg/L, respectively. In Clarke County (N 31° 52' 55" W 88° 41' 15") an old capped well was located on a ridge within the channel. Temperature of the well was 19.8°C, salinity was 0.4 ppt, and DO was 3.80 mg/L. Cooling effects of the well beneath the surface were minimal. Water temperature of the river below the well was only 0.6 degrees cooler than upstream of the well, and DO and salinity remained unchanged. Otherwise, water temperatures of the Chickasawhay River ranged from 28.3°C to 31.7°C. Salinity ranged from 0.0 ppt to 0.1 ppt. Dissolved oxygen ranged from 4.36 mg/L to 6.04 mg/L. One of the radio tagged fish moved downstream into the east fork of the Pascagoula River before it died. The other fish moved upstream in the Chickasawhay River before it died.

No thermal refuges or springs were located in the Leaf River. Water temperatures ranged from 27.3°C to 33.2°C. Salinity was 0.1 ppt and DO ranged from 3.73 mg/L to 4.67 mg/L. One radio tagged fish moved upstream in the Leaf River before it died. The other radio tagged striped bass in this system has not been relocated.

Gravel pits below the old Hercules Dam on the Bouie River also were surveyed. In these pits, surface water temperatures ranged from 29.3°C to 31.7°C. Water temperatures to a depth of 7 m ranged from 28.5°C to 28.9°C. Dissolved oxygen ranged from 1.61 mg/L to 4.1 mg/L, and salinity was 0.0 ppt. A pit away from the main flow of the river had a water temperature of 22°C and a DO of 0.0 mg/L at a depth of 5 meters. No habitat suitable as thermal refuge for striped bass could be located.

Black Creek's water temperatures ranged from 28.6°C to 31.5°C. Salinity ranged from 0.0 ppt to 0.1 ppt. Dissolved oxygen ranged from 4.51 mg/L to 7.19 mg/L. Of the radio tagged fish released into Black Creek, one may have moved temporarily into Bluff Creek, but this was questionable, because radio contact was lost after a period of 15-30 seconds. The other radio tagged fish has not been located.

One potential refuge for striped bass was a backwater area on Sweetwater Creek (N 30° 49' 60" W 88° 50' 32"). Water temperatures were 25.3°C to 25.6°C. Salinity was 0.0 ppt, and DO ranged from 4.6 mg/L to 5.0 mg/L. Depth was a maximum of 2 m, and flow was detectable in shallow areas only.

Red Creek's water temperature ranged from 27.9°C to 29.5°C, and salinity was 0.0 ppt. Dissolved oxygen ranged from 3.36 mg/L to 4.85 mg/L. Sections of Red Creek are yet to be surveyed, but no radio tagged striped bass were located during the aerial survey. Both of the striped bass released into Red Creek have demonstrated movements downstream. One of the transmitters was recently located in the Pascagoula River at Ward Bayou. The other radio tagged fish was located at the mouth of Red Creek.

While numerous cool water creeks were located along all of the rivers and creeks, they are too numerous to list in this report. Their potential as thermal refuge for striped bass is unlikely, due to the small size of these waters.

As of 24 August, 1998, 104 angler interviews have been conducted. Catfish species were the most targeted fish with 53% of the respondents indicating catfish as their target species. The preferred method for catching catfish is passive gear (i.e., trotlines and limblines). Bream (centrarchid sunfishes) are the second most targeted fish group, with 26% of the respondents so indicating. Anglers seeking "bass" or "any species" tied for third, with 8% each of the respondents targeting them. The remaining 3% was divided among anglers seeking red drum, speckled trout, or soft-shell turtles. No effort was directed toward striped bass, nor were any anglers in possession of a striped bass when interviewed. In fact, the striped bass was considered undesirable for eating by many anglers. However, 29 interviews indicated catching a striped bass at sometime, predominantly in the spring. Eighteen of these interviews indicated the use of live bait on a trotline as the method for catching striped bass. The other 11 anglers with striped bass catches were actively fishing for other fish species.

## Conclusions

Thermal refuges appropriate for striped bass in the Pascagoula River and its tributaries seem to be uncommon and of limited size. Movements of striped bass, based on telemetry data, indicate that thermal refugia may exist in the Chickasawhay River. Electrofishing suggests that Mounger's Creek may also serve as a thermal refuge. There is also suspicion that striped bass may move downstream seasonally, attempting to locate cooler water in the Gulf of Mexico. To address this, it may be necessary to equip fish with sonic rather than radio tags.

Striped bass catches by anglers fishing in the system are uncommon and typically within the category of bycatch. Most documented catches of striped bass to date have been associated with the use of live bait on trotlines. Potential may exist for significant hooking mortality of striped bass that are captured by this technique and subsequently released as undesirable fish by local anglers.

## Wrap-up and Discussion

D. Frugé - We would like to use this time to entertain any additional questions, comments, advice, feedback, whatever anybody might want to contribute regarding any of the presentations, the Commission, or the FMP. To set the stage, I thought I would go through a cursory summary of all the presentations that we had.

We started off with Sidney Montgomery yesterday afternoon, he gave us a presentation on striped bass fishing in the Mississippi River. He noticed striped bass became quite abundant in the lower Mississippi River in the Vicksburg stretch of the River in the late 1980s, but then several years ago, about 1994 or 1995, they started becoming pretty scarce. That situation has continued to this time.

Pete Cooper gave us a presentation on striped bass fishing in the extreme lower Mississippi River in the Delta area, and he indicated that striped bass first started showing up in that area in the late 1960s. The fish that he has seen being caught or has caught himself have been relatively small. However, he thinks that there are some big fish in the river. The problem is that no one in the area really knows how to access those fish. The striped bass fishery in the lower Mississippi River is largely underdeveloped and underutilized.

Dr. Coutant gave us a presentation on his work with striped bass in reservoirs and experience with their, especially the larger fish over five pounds, need for cool water in order to survive the summer time conditions in the Southeast. Thermal refugia are especially important for the larger fish over five pounds.

Dr. VanDenAvyle gave us a presentation on his experience with trying to restore a striped bass fishery in the Savannah River. They looked at the cost effectiveness of stocking various sizes of striped bass fingerlings and found that they had the best cost effectiveness and relative survival with larger phase II fish stocked in fresh water.

Paul Mauck gave us a presentation on the striped bass fishery in Lake Texoma. They have noticed continuous reproduction of striped bass in that system since 1974. Some years have been better than others, but they have had spawning in both the Red and the Washataw systems that feed into Lake Texoma. They have a very successful fishery there.

We then heard from Jim Bulak who talked about his experience with the Santee-Cooper Reservoir striped bass fishery. He indicated that the recruitment into the fishery from natural reproduction is dependant on timing of hatching and hydrological conditions at the time. It was really dependant on environmental conditions at time of hatching. Relativity few females were needed to produce the recruits to the wild population in that system.

Dave Yeager talked about the fishery that has been established in the Blackwater and Yellow Rivers in Florida. They have been stocking fish since 1987 in the Blackwater and since 1992 in the Yellow. Fish stocked have been surviving and growing to maturity, and a modest fishery has developed. They have implemented a targeted angler diary program to keep tabs on the fishery and plan to expand that angler diary program in the future.

Charlie Mesing talked about the Lake Talquin study where the Florida Game and Fresh Water Fish Commission (now the Florida Fish and Wildlife Conservation Commission) looked at relative growth, survival, and condition of Gulf and Atlantic race striped bass in Lake Talquin. Although there were some minor differences found, they found no consistent differences in total length, weight or condition to age 5 in that system. They did find that using genetic tags was a very useful tool and have gained experience using genetic tags with striped bass.

Bill Davin gave us a presentation on striped bass reproduction in the Coosa River system. They found that natural recruitment is occurring in that system and that the naturally-spawned Atlantic origin fish are probably moving down that system into the lower reaches.

Dr. Wirgin talked about his work with genetic analyses on striped bass. He has found mitochondrial and nuclear DNA markers that are unique to the Apalachicola-Chattahoochee-Flint River system for striped bass. Using data collected through 1995, only that system contains fish with the unique genetic marker for the mitochondrial DNA in the Gulf. Even though some Atlantic race fish were introduced into that system in the 1970s, there has been no significant introgression of Atlantic genotypes, at least using mitochondrial DNA as an indicator, in to that system. He has also found that the micro-satellite technique potentially can provide an unlimited number of DNA markers for future studies.

Jim Williams talked some about taxonomic considerations of Gulf striped bass. He indicates that there is evidence for the distinct character of Gulf striped bass populations in the Apalachicola-Chattahoochee-Flint system. We really need to look more in depth at historical material from other river systems to draw some good conclusions regarding the question of taxonomy of the Gulf race.

Getting into the stewardship projects Rick Long talked about their work in the Apalachicola system. They have found that restoration of striped bass there is dependant on stocking fish in Lake Seminole. Natural reproduction probably cannot sustain the fishery that has been created in the lower Apalachicola River. The young-of-the-year index is a good indicator of year class strength, and the tailrace creel is really dependant on year class strength and dam discharge from the reservoir.

Cecil Jennings then talked about their studies of striped bass reproduction in the Flint River system. They have been sampling for striped bass eggs and larvae, but have not found any based on one year of sampling, although they still have a number of samples yet to process. The data to indicate that hydrological conditions were sufficient to trigger spawning, but cool conditions in spring of this year may have caused some sporadic or delayed spawning of striped bass in that system. That project also involves questions regarding possible impacts of striped bass on the trout fishery in the upstream portion of that system.

Howard Rogillio talked about the Louisiana Department of Wildlife and Fisheries work in the Pearl and Tchefuncte River systems. They stocked Phase I fish in the Pearl in the first year and in the Tchefuncte in the second year. They have radio tagged two fish which were released into the Tchefuncte River, one which died and one which they are still tracking.

Fred Monzyk talked about the Louisiana Cooperative Fish and Wildlife Research Unit project in the Pearl and Tchefuncte systems. They found growth of striped bass in that system as good as or better than in many other populations that have been recorded. He has found mature males and females in spawning condition in the Tchefuncte River; however, in the Pearl River he has not found any larger or any older than age two.

Larry Nicholson gave us a presentation on his project in the Pascagoula and other Mississippi coastal rivers. He has grown out fish in a raceway system at the Gulf Coast Research Laboratory and compared growth and survival of the reared fish. He has also stocked Phase I and Phase II fish into the Pascagoula and some of the other rivers. He has seen some differences in growth and survival between the Atlantic and Gulf races in the culture system, but really doesn't have any conclusions at this point. There have been problems with air bladder inflation and also deformities of a number of fish. He reports that over the last year he has gotten reports from fishermen of 708 striped bass or hybrids being caught in Mississippi coastal rivers. A majority of those are from the Pascagoula.

Finally, John Mareska reported on Mississippi State University's study on the Pascagoula system. He concluded that striped bass is not a target fishery species in the Pascagoula River based on their creel work. There may be high hooking mortality from trotlines in the Pascagoula. Thermal refuges in that system, based on their telemetry work and other temperature surveys, are extremely limited.

With that and the last slide from my presentation yesterday morning with some of the questions that I still have regarding striped bass in the Gulf, I throw it open at this point to any questions that anyone might have of any of the speakers that presented over the last couple of days and any feedback discussion or comments anyone would like to make.

**R. Lukens** - We have two target areas for the workshop. One is based on what progress we have seen with the stewardship projects. Is there a major shift that needs to take place, in anybody's mind; is there something we are overlooking? Secondly, we want to capture all the thoughts and ideas and information sources that we can to begin the process of revising our striped bass fishery management plan beginning next year. We are only starting the process next year. We won't actually go into full revision and our internal GSMFC process until some time after that. Next year we will conduct a review of the existing FMP and determine the scope of work that will be required. We would like for you to give us your thoughts and ideas about that.

**C. Coutant** - With thermal refuges being so important in the summer, I would be curious to know if anybody is trying to create additional refuge area, rather than simply look for ones that are there. In other words, is anyone thinking of creating them as a management tool. For example, groundwater sources are good. Is anybody thinking of pumping groundwater sites? Are we considering expanding small refuge sites and making them more effective for the fish by creation of underwater dams or other barriers that would contain that cool water?

**C. Mesing** - I know Georgia has been actively involved in looking at springs in the Flint River, and they would like to look more in Lake Seminole. They cleaned out a very large thermal refuge off of the Flint River. We are attempting to do some of that work on the ACF. In the Apalachicola River most of these refuges are above the dam, but below the dam we have 10 creeks. We had the Corps of Engineers (COE) dig out the mouth of one spring to make a pool where literally hundreds of striped bass come and stay for periods of time. It is the start, and we are trying to get the COE to do at least 4 of these creeks each year. It would be nice to go out there and drill a hole through the limestone rock below the dam, because in 1954 when they built the dam, they brought the cement trucks in and filled the springs to stabilize the area to build the dam. It would be nice to get those springs back.

**R. Lukens** - Chuck, in regard to thermal refuges, you can see with some of the work that is going on that one of our biggest problems is not knowing if we have any or where they are if we do. We have historical information that tells us striped bass were here long ago, and if that is the case, then conditions were acceptable for them at that time, apparently. You have to step back and say what changed, and we know a lot of things have changed. For instance, in the Pascagoula River, are there thermal refuges, and if so, are they spring fed ground water or are they cool streams? If they are cool streams, are they spring fed streams or are they cool because of the overstory? These are very basic questions that we don't have answers to for a lot of river systems in the Gulf. Beyond that, taking the next step, when we do find something that appears to be a thermal refuge, we need to characterize it in terms of size, environmental condition, and its use by fish. Then we can take the next step, such as perhaps closing areas to fishing during the summer or developing other regulatory measures. I am concerned that we just don't have a lot of basic knowledge of the river systems themselves in terms of the needs of striped bass being a thermally challenged fish in the summertime.

**D. Frugé** - One of the things that is of interest to me about the Pascagoula River is that it is one of the last rivers of moderate size in the northern hemisphere that hasn't been dammed. It is still an unregulated river. It has not been channelized or dammed. It should be a strong candidate for successful striped bass restoration.

**R. Lukens** - You saw Larry Nicholson's slide that indicated that there have been a number of fish reported being caught up around Glendale, Mississippi, which is near Hattiesburg. That seems significant to me, and so far, we haven't done any work to characterize that area. I think we need to mount an effort at some point to go further up and look at those areas, characterize them, and find out why striped bass are there.

**C. Coutant** - I have a suggestion on finding thermal refuges. I am not sure it will work this far south, but ground water sources are usually warmer than ambient temperature in the winter time. If you can get infrared imagery or aerial photography that is temperature sensitive in the winter, you can actually find the summer thermal refuges in which the cool water tends to sink, by going out in the winter when the warmer water tends to rise to the surface.

**R. Lukens** - How do you acquire the imagery?

**C. Coutant** - You can acquire the imagery using an airplane with thermal imaging equipment. The service is available commercially.

**R. Lukens** - We did a project like that several years ago on the Apalachicola River. We used the TIMS - Thermal Infrared Multispectral Scanner - on a Lear Jet. We had some operational problems. I think we were flying too high, and we had a lot of ground fog that tended to block the signal in certain reaches of the river. We were unable to get a good reading there. We know that it worked, because it clearly showed power plant effluent, but it was not as effective for known thermal refuges.

We used the Apalachicola River, because we knew something about thermal refuges there. Unfortunately, it really didn't pick out all that many that we knew were there. But then again, it picked out a couple of them. I think if we could have flown lower and gotten higher resolution we might have done better. In terms of the cost, it is very expensive, and there is a pretty heavy processing load once the data are acquired to get it in a form where you can make assessments.

**C. Mesing** - I think it is most important to get adult fish at least five pounds and larger in the water while it is cool, so they can survive the stress, temperature, and handling. They will find cold water if it is available.

**R. Lukens** - So thermal refuge availability falls into the category of limiting factors up here on our question, and certainly there have to be others. Are we concluding that thermal refuge availability may be the largest limiting factor, along with migration routes being blocked? I listen to the Pearl presentation and they gather up behind the sill just like they gather up behind the dams. That phenomenon is telling us they want to go upstream.

In terms of an FMP, you can tell we don't have a large constituency that fishes these striped bass. There are some people that we know who target them, but comparatively speaking, there are significantly more people that target red drum, speckled trout, and others, as Pete mentioned. The constituency is not there; therefore, it is difficult to build interest in the fish from a management perspective. The fact that there are not a lot of people catching them makes it difficult for us to learn more about their abundance, so we are probably never going to have answers to questions of historical abundance. We still grapple with the question of what is our restoration target. I think that is directly tied to habitat availability or carrying capacity. Is there any experience in reservoirs that would be applicable to help us address the issue of habitat limitations in the FMP revision? For thermal refuges, has anybody come up with a carrying capacity per cubic foot of thermal refuge? Is that doable?

**C. Mesing** - It varies, Ron, from year to year. Some years you may get stratification at one depth, but it changes in subsequent years. When you get variable conditions, you get population variability. It is up to the ability of the fish to fight its way through the extremes and maintain itself. I think it is hard to put a number on a particular refuge because things are so variable. There are a lot of environmental conditions that fluctuate in those refuges.

**C. Coutant** - Food availability is turning out to be important too. If these fish have gorged on shad in the cool season, they go into the summer with plenty of fat reserves. Since they likely don't feed while in the refuge, they can last longer through the summer having eaten well beforehand. If forage has been marginal, or if the shad are low in abundance, they don't enter the summer with plenty of fat, and they have a higher potential for mortality.

**H. Rogillio** - What keeps striped bass from moving out into cooler water in the Gulf?

**P. Cooper** - It may not be cooler in the Gulf?

**R. Lukens** - There are records of striped bass being caught off Mississippi around Horn and Ship Islands, but they are rare.

**R. Long** - Is there always cooler water below dams?

**C. Mesing** - The turbulence from dams can also provide a cooling effect.

**D. Frugé** - On the Sabine, we had 20 fish radio tagged over a two year period. Most of those survived. Essentially the only thermal refuge in the area was right below the dam.

**C. Mesing** - Did they go to the Gulf?

**D. Frugé** - They left the system; we don't know exactly where they went. We lost track of a number of them over the winter but they showed up again in the spring. We assume they went either into the Gulf or the nearshore coastal waters where we couldn't pick up the radio signals anymore.

**R. Lukens** - We might want to use sonic tags in the future to see if they are going out of the Pass into coastal waters. Also, we know that Larry Nicholson has some tagged fish from the Biloxi system, that ended up in the Pearl River. So, we know that they are going out into the coastal area and moving laterally along the coast.

**General** - There ensued a discussion regarding a relatively new technology of analyzing otoliths to determine their chemical composition. That can be used to correlate with where certain compounds may have been acquired in the otolith as a potential tool in determining movements.

**C. Coutant** - What you are actually doing is getting at the chemical composition of a very fine spot. Otoliths work best; you can actually get down to 10 micron distances on the otolith. Wherever the spaces are in order, you get a chemical ratio that indicates freshwater versus saltwater. There is a fair amount of variability, but if you are trying to make a distinction between freshwater versus saltwater as opposed to where they are in the estuary, it can work well.

**R. Lukens** - I wanted to get some feedback on the implications of Jim Williams presentation. We have as much if not more genetic information on striped bass in the Gulf of Mexico than most wild animals I know of. We have discussed the issue of sub-specific designation for awhile, and it seems to me that Jim's presentation lends a lot of support to the idea. What are the management implications of pursuing a taxonomic evaluation of Gulf striped bass? What is the general feeling of this group about pursuing that particular issue over the next several years?

**I. Wirgin** - From a management perspective, is it good to be a subspecies or not?

**R. Lukens** - It depends on the direction management goes. Striped bass are not abundant in the Gulf area. We have the Apalachicola system plus fish that we have stocked in other streams. I think the most important implication is if you look at the possibility of listing the species. I guess you would look at it in the same way you would Atlantic sturgeon or Gulf sturgeon in a listing situation; however, I don't think anybody is prepared to pursue that.

**C. Mesing** - I would offer up this. The issue of listing was brought up several years ago, and the states opposed it. Their main concern with listing was the potential impacts on Atlantic programs and supplying fish for the Gulf coast and *Morone* hybrids. This leads me to a question. We have an objective in the fishery management to achieve self-sustaining populations in Gulf river systems, and to assess that condition using existing data. All the data presented at this workshop appears to indicate that the Atlantic fish are much better at reproducing in Gulf systems than Gulf fish are. At least in the case of the Lake Talquin study, it appears that in certain instances Atlantic fish may be better adapted to some of these altered Gulf systems. If that is the case, by seeking subspecies status and listing the fish you may prevent a successful program with Atlantic race fish which is already ongoing.

**R. Lukens** - I guess this may be a good topic for pursuing in the context of the FMP. Right now everyone has a choice. If Gulf fish are not available, they can get Atlantic fish to stock. There is some logic behind the idea that if you are going to work with one genetic strain, then work exclusively with one, don't stock both. I am not willing to say, based on what I have heard here, that Atlantic fish reproduce better than Gulf fish. There may simply be more Atlantic fish available in most of the river systems than Gulf fish.

**D. Frugé** - There is a philosophical component to this question as well. It gets to evolutionary significance of the Gulf race and the perspective of whether it performs better or is better adapted to Gulf rivers. As Charlie pointed out, maybe with the altered systems now the Atlantic race is better suited for survival and reproduction. Do we not still have an obligation to try and preserve that Gulf genetic material? Maybe these systems won't always be the way they are now. Some of them may go back to the way they were in the historic past, because dams don't last forever?

**R. Lukens** - Forget, for the moment, the comments about listing. I was just saying that that is an applicability of looking at the taxonomic distinction. In the overall context of doing striped bass work in the Gulf, given the information that we have, is looking at the taxonomic status of striped bass in the Gulf something that we should consider?

**I. Wirgin** - We should look at other historical specimens.

**R. Lukens** - At least at this point, we think we have samples from all available specimens.

**I. Wirgin** - You should consider looking for scales of early specimens.

**R. Lukens** - That would be the only other alternative I could think of, because I think we did a pretty good job of finding available specimens. Let me ask the question this way. If we find that we don't have additional specimens or samples, does that mean it is not worth pursuing, because we only have one system that displays this particular genetic material? Is it still worth pursuing with the assumption that there would be a fair amount of homogeneity within a regional striped bass population? Is that too big an assumption?

**I. Wirgin** - Yes, that is a big assumption, but I don't think anyone knows the answer to that question.

**R. Lukens** - I am trying to get to a general sense, assuming that we don't find any additional specimens or samples, of whether or not we should keep this as a priority over the next several years. Is it worth doing if it only addresses the striped bass population in one river system?

**I. Wirgin** - I don't think it decreases the importance at all.

**J. Mareska** - I propose the idea that you refer to the Apalachicola race rather than the Gulf race until we can get some further evidence.

**C. Coutant** - We admit that taxonomy is a creation of our own individual thinking. We have shown that they are genetically different. Clearly you can go back to the basic genetics study and there are differences, but we are still stuck with a functional question. Does the fact that you have some differences in the biochemical genetics translate into anything functionally different. It should have or it wouldn't have existed in the first place. I would like Ike to comment on that.

**I. Wirgin** - There is a functional difference if you consider the egg buoyancy issue.

**R. Lukens** - Is the riverine fidelity versus true anadromous behavior environmentally driven or is it another functional difference that we should consider?

**I. Wirgin** - That is an important question which should be considered.

**D. Frugé** - I recall Dr. VanDenAvyle saying, yesterday, that the Savannah population behaved the same way. They don't appear to migrate out into the ocean very much.

**R. Lukens** - In the context of fisheries goals and management considerations for revising the FMP, I would like to get some feedback. We have recommended a prohibition on the sale or purchase of striped bass caught in the Gulf region. To my knowledge the only state that doesn't overtly prohibit the purchase is Alabama. But the reality is there is no market for striped bass in the Gulf, and nobody is actually commercially harvesting to my knowledge. Correct me if I am wrong, are there people selling striped bass?

**Speaker Unknown** - We find striped bass in grocery stores in New Orleans.

**D. Frugé** - Remember, there is some aquaculture product available.

**R. Lukens** - So, my assumption is that we should keep the no sale provision (no objection from the audience). We also have a bag limit of 6 fish per person per day with a minimum size limit of 18 inches. Arguably we could go to a larger size limit if we are looking for more spawning capacity, but the reality is that in most cases most people are not catching 6 fish a day anyway. Should we consider changing this regulatory recommendation when you consider what people are actually catching? One final question is should we continue stocking fish into systems in which we feel that there probably won't be any natural reproduction? Our goal is 10 million stocked fish with at least 500,000 being Phase II fish. We actually want more Phase II fish. Should we continue with that stocking goal?

**C. Mesing** - I would propose we continue evaluating lethal temperature and mortality or carrying capacity. Over the next several years we might be able to eliminate certain systems based on the fact that there is insufficient thermal habitat to achieve reproducing populations.

**R. Lukens** - That's presuming we think we have been successful in either uncovering what is there or covering the river so well that we know nothing is there, which I don't believe is the case at this point. I still go back to the fact that in the river systems that we selected we historically had reproducing populations of striped bass. There must have been something back then that contributed to that success, even though there weren't large populations like the Chesapeake, or generally the Atlantic coast. Are our systems irretrievably altered to the point that that no longer is the case -- we simply don't have suitable habitat and never will? I don't know the answer to questions like that.

**C. Coutant** - I just want to make a comment on the telemetry studies. We are probably being too conservative on the number of fish we tagged. We really need to find out where these refuges are. We should tag fish in the hundreds, not 3 or 4. We've got so few fish out there, it is hard to learn much from them. It may be that we are sacrificing all those fish for the sake of locating thermal refugia, assuming that if they don't find suitable thermal habitat they will die, but it is critical information.

**C. Mesing** - The fact is I can't get 100 fish. If we had 100 fish available from a hatchery, would you put a radio tag in them and see if they find cold water.

**C. Coutant** - Yes, if you are really trying to test the system.

**C. Mesing** - I think the importance of cold water is not if they are hatchery fish or wild fish. I agree we need to get the fish in the water so we can learn something. It is more important to get as many striped bass as we can tagged with a radio transmitter, because it will find cold water or it will die. I don't think it invalidates the study just because you use a hatchery fish.

**D. Frugé** - I wish we had programmed more time for discussion, but we need to conclude. I think this has been a very interesting day and a half. I want to express my appreciation to everybody who attended, and especially everybody who made presentations, particularly the folks that traveled considerable distances to get here. As I said yesterday, our intent is to hold another workshop to focus more specifically on some of these questions after completion of the Stewardship Initiative projects. We may have a different format, one that is more focused on decision-making or answering specific questions. You will all be invited to participate in that. You all will receive a summary of this meeting, as soon as the GSMFC can complete it. I want to also thank everybody for staying on schedule.

**R. Lukens** - I want to thank you too. The GSMFC appreciates your participation in this workshop. The more we do with striped bass the more I am struck by the fact that we don't know very much at all about the environment into which we are putting these fish. I guess we need to start focusing on learning more about the river systems and habitat status, and I think the content of the presentations over the last day and a half supports that assumption. Thank you very, very much and please contact us if you think of anything in addition to our discussions here that would be useful. Thank you.

*In many cases, speakers during the wrap-up session could not be clearly heard because of the acoustics of the room and their proximity to the microphone for the recording system. In those cases, comments and questions from those speakers were deleted from these proceedings. To those speakers, we sincerely apologize.*

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Table 1
Mortality rate of Phase I fish held in live car for 72 Hours after stocking

| Date | Mortality | River Temp. Degrees F° |
|---|---|---|
| June 12, 1997 | 3 Died | 79° |
| June 13, 1997 | 0 Died | 79° |
| June 14, 1997 | 3 Died | 81° |
| | | Released 99 of 105 (94.28% survival |
| June 4, 1998 | | 81° |
| June 5, 1998 | | 82° |
| June 6, 1998 | 4 Died | 83° |
| | | Released 96 of 100 (96% survival) |

Table 2
List of potential Phase I striped bass - captured five weeks after stocking

| Date | Location | # Striped Bass | Size Range |
|---|---|---|---|
| 7-22-97 | below lock I to I-59 | 0 | 0 |
| 7-31-97 | I-59 to Davis landing | 0 | 0 |
| 8-5-97 | Crawford landing to Hwy. 190 | 0 | 0 |
| 8-19-97 | West Pearl river @ Nav, Canal Lock I | 1 before sunset | 70 mm |
| 8-13-97 | West Pearl river @ Nav, Canal Lock I | 4 before sunset<br>2 after sunset | 89-115 mm |
| 7-08-98 | Bogue Falaya River | 7 before sunset<br>0 after sunset | 80-90 mm |
| 7-14-98 | Bogue Falaya River | 18 before sunset<br>13 after sunset | 58-110 mm |
| 7-21-98 | Bogue Falaya River | 0 before sunset<br>13 after sunset | 84-109 mm |
| 7-29-98 | Bogue Falaya River | 2 before sunset<br>2 after sunset | 74-104 mm |
| 8-06-98 | Bogue Falaya River | 1 after sunset | 101 mm |

**Table 3**
Record of striped bass harvested

| LENGTH (mm/in) | WEIGHT (g./lbs.) | Location (River) | DATE | GEAR (net, hook-n-line) |
|---|---|---|---|---|
| 655<br>25.78 | 5035<br>11.1 | Lake Pontchartrain | 2-13-98 | gill net |
| 656<br>25.82 | 4312<br>9.5 | Tchefuncte River | 4-2-98 | gill net |
| 745<br>29.33 | 7004<br>15.44 | Tchefuncte River | 4-2-98 | gill net |
| 675<br>26.57 | 4962<br>10.94 | Tchefuncte River | 4-2-98 | gill net |
| 712<br>28.03 | 4938<br>10.89 | Little Tchefuncte River | 4-21-98 | gill net<br>radio tagged |
| 605<br>23.82 | 3146<br>6.94 | Little Tchefuncte River | 4-22-98 | gill net<br>radio tagged |
| 464<br>18.27 | 1260<br>2.78 | Bogue Chitto sill | 7-7-98 | hook-n-line |
| 421<br>16.57 | 841<br>1.85 | Bogue Chitto sill | 7-7-98 | hook-n-line |
| 451<br>17.76 | 963<br>2.12 | Bogue Chitto sill | 7-7-98 | hook-n-line |
| 460<br>18.11 | 1090<br>2.40 | Bogue Chitto sill | 7-7-98 | hook-n-line |