Grass Carp Collection, Aging, and Growth in Large Water Bodies—A Status Report for 1992-1993

by

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Introduction

In recent years, triploid and diploid grass carp (*Ctenopharyngodon idella*) have been stocked in reservoirs and lakes to control nuisance aquatic vegetation such as hydrilla (*Hydrilla verticillata*). The U.S. Army Engineer Waterways Experiment Station (WES) developed a grass carp stocking model (Boyd and Stewart 1992), but need objective data to refine the model for different regions and types of vegetation. This report summarizes efforts during 1992 and 1993 to obtain basic biological information on grass carp that will be used to refine the stocking model.

Our objectives were to develop cost-efficient collection techniques, length-to-weight relationships necessary for use in backcalculation, and methods to age the fish. As these techniques are developed and information gathered, estimates of growth, mortality, and standing stocks of grass carp in large water bodies will be made available to refine the stocking model.

Methods

Grass carp were collected from two major reservoir systems, Lake Guntersville, Alabama, and the Santee Cooper reservoirs (Lakes Marion and Moultrie) in South Carolina. Lake Guntersville is a 68,000-acre reservoir in northern Alabama managed by the Tennessee Valley Authority. A total of 118,400 diploid and triploid grass carp were stocked between 1988 to 1990 to control hydrilla.[2] The Santee Cooper lakes total approximately 170,000 acres and have a major hydrilla infestation. Lake Marion was stocked with 100,000 triploid grass carp per year from 1989 through 1992 to control hydrilla. An additional 50,000 triploid grass carp were stocked into Lake Moultrie during 1993 to control spreading colonies of hydrilla.

An initial problem was collecting adequate numbers of triploid grass carp using traditional sampling gears. As part of a grass carp monitoring program (Morgan and Killgore 1990), vegetated areas of Lake Marion were extensively electrofished. In addition, the South Carolina Wildlife and Marine Resources Department (SCWMRD) regularly conducted gill net, cove rotenone, and electrofishing sampling of the Santee Cooper system. Although some grass carp were collected by each of these methods, the numbers collected were inadequate for research needs.

Triploid grass carp were accidentally harvested during bowfishing tournaments in 1990. As a result, bowfishermen were used in a final attempt to collect triploid grass carp. The collection was organized and permitted by SCWMRD. Bowfishing teams familiar with the reservoirs and who had consistently won local bowfishing tournaments were recruited and paid for their efforts.

The collection efforts took place at night using a boat with five lights powered by a small gasoline-powered generator. Bowfishermen stood on the bow of the boat and maneuvered into coves and along shallow flats looking for grass carp. Fish were generally collected in coves and other confined areas as they swam by the boat. Fish had to be quickly identified and shot in depths up to 6 ft. Once the fish

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was shot with a conventional bowfishing arrow, it was played on a line using a reel attached to the front of the bow. After the fish tired, it was reeled near the boat, shot a second time to prevent escape, and then gaffed. Collected fish were processed the next day. Biological information, to include a survey of stomach contents, was collected by biologists.

Length-to-weight relationships are used to indicate the condition or "plumpness" of a fish population (Le Cren 1951). Another use is to predict weights of fish of a given length determined by backcalculations using scales or otoliths. Total lengths to the nearest millimeter and weights to the nearest gram were measured for each fish collected. The length-to-weight relationship was computed using a power function (Ricker 1975):

$$\text{Weight} = \text{intercept} \times \text{Length}^{\text{slope}}$$

Generally, fish are aged by examining annual marks on scales, otoliths (ear bones), or other bony structures (Jearld 1983). However, we did not find any information on grass carp aging techniques and little information on growth rates. Consequently, we evaluated the potential of otoliths and scales as aging structures to develop grass carp growth and mortality information.

Age and growth information presented in this paper was obtained by examining scales; we did, however, compare ages determined from otoliths and scales from grass carp collected in Lake Guntersville. Scales had consistently recognizable annuli and were examined by projecting their image on a microfiche projector. Distances to each annuli and distance to the margin of the projected image were measured using a GP-7 graphbar digitizer and a personal computer. The computer is equipped with a series of basic programs used to measure structures and backcalculate lengths of fish. Backcalculated lengths were estimated using the Fraser-Lee Method (Carlander 1982) which uses the following formula:

$$Li = a + (Lc - a/Sc)Si$$

Where

Li = calculated length at age i

a = intercept of the body scale regression

Sc = diameter or radius of scale at capture

Lc = length of the fish at capture

Si = scale measurement at annulus i

Results

Electrofishing, netting, and rotenone were unsuccessful in collecting sufficient numbers of grass carp (Kirk et al. 1993). Skilled bowfishermen proved an effective, cost-efficient method to collect grass carp. A total of 69 and 125 triploid grass carp were collected in Lakes Moultrie and Marion in 1992 and 1993, respectively. Substantially less effort was expended on Lake Guntersville where tournament bowfishermen were not recruited in time to make a concerted collection effort. However, 43 grass carp were shot during a bowfishing tournament in April 1993, and these fish were used to provide initial estimates of age and growth.

The length-to-weight relationship for grass carp from Santee Cooper collected during 1993 has not yet been determined. The length-to-weight relationship for fish collected on Lake Guntersville follows:

$$\text{Weight} = 0.0000045\ \text{Length}^{3.163}$$

The relationship for Santee Cooper triploid grass carp collected in 1992 follows:

$$\text{Weight} = 0.0000027\ \text{Length}^{3.25}$$

After calculating the length-to-weight relationship, we backcalculated lengths and weights for grass carp from Lake Guntersville using scales and otoliths from the 43 fish. Table 1 compares age-specific sizes for the Santee Cooper reservoirs and Lake Guntersville for grass carp collected during 1992 and 1993. Grass carp in the Santee Cooper reservoir are growing more rapidly.

Table 1
Age-Specific Lengths and Weights of Grass Carp from Lake Guntersville, Alabama, and the Santee Cooper Reservoirs, South Carolina

	Lake Guntersville		Santee Cooper	
	Length mm	Weight g	Length mm	Weight g
Age I	311	339	361	547
Age II	596	2,699	698	4,894
Age III	746	5,491	821	8,294
Age IV	845	8,144	908	11,506
Age V	899	9,907	n/a	n/a

Sagittal otoliths of cyprinids often show no clear marks and are not suitable for age determination. When aging cyprinids, the lapillus (utricular otoliths) should be used (Victor and Brothers 1982). The lapillus appears to lay down annuli and should be a suitable aging structure to compare with scales. Figures 1 and 2 show all three otoliths and a sectioned lapillus, respectively. Almost complete agreement existed in ages determined from sectioned otoliths and scales from fish collected from Lake Guntersville.

Discussion

Skilled bowfishermen are an effective method of collecting grass carp in large water bodies. We intend to expand our collection efforts and increase sample sizes in both systems in 1994. Instead of relying on grass carp collected at Lake Guntersville bowfishing tournaments, we will attempt to contract with individual bowfishermen and collect between 100 and 200 fish during 1994.

Initial estimates of growth strongly suggest that grass carp in the Santee Cooper reservoirs are growing at a much faster rate than in Lake Guntersville. This may be related to the availability of preferred foods. Some fish collected from Lake Guntersville in early April 1993 were eating filamentous algae and other less preferred foods (Sutton and Vandiver 1986; Leslie et al. 1987) Hydrilla, a preferred food of grass carp, is almost entirely gone from Lake Guntersville, while extensive stands of Eurasian watermilfoil (*Myriophyllum spicatum*), a less preferred food, is not being consumed by grass carp. Hydrilla in the Santee Cooper system is being controlled in upper Lake Marion, but is rapidly expanding into other parts of the system, especially Lake Moultrie. Thus, a preferred food is not limiting in this system.

Preliminary results suggest that scales and otoliths are suitable for aging grass carp, and research is ongoing to validate these aging structures. There was high agreement between sectioned utricular otoliths and scales; the backcalculated length of Age I fish was very close to the length of known Age I fish stocked into the Santee Cooper reservoirs and Lake Guntersville.

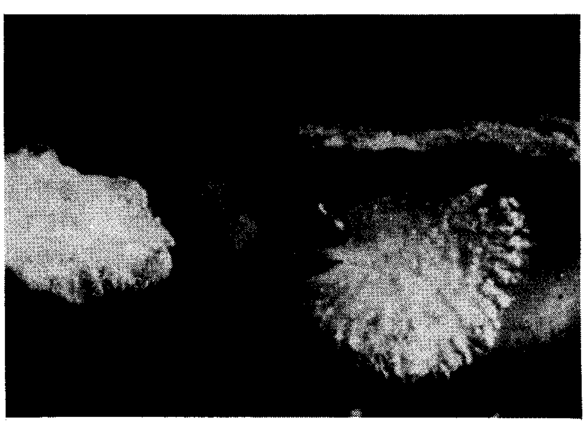

Figure 1. A view of grass carp otoliths. Left most is lapillus, right top is asteriscus, and right bottom is sagittus.

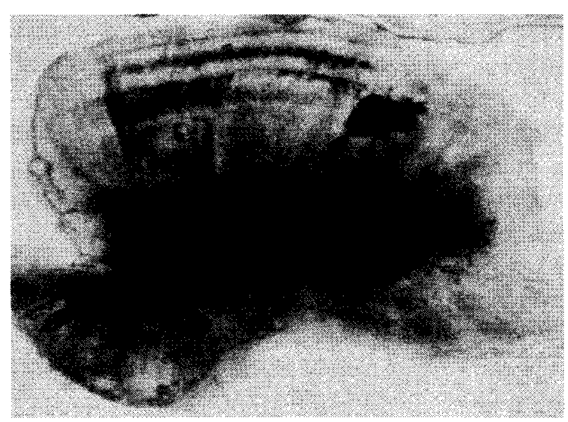

Figure 2. Sectioned utricular otolith (the lapillus), showing annuli

Future efforts will focus in several directions. Scales and otoliths require validation. Fish collected from the Santee Cooper system in 1993 and fish to be collected from both systems in 1994 must be aged to generate growth and mortality estimates. This information can be incorporated into a Ricker Table (Ricker 1975) to provide estimates of numbers, biomass of grass carp by age class, and total grass carp biomass. The primary relationship used to derive these estimates follows:

$$N_t = N_0 e^{-zt}$$

This relationship states the number at time (t) is equal to the initial number (0) raised to the instantaneous rate of total mortality (z) times the number of years (t) (Ricker 1975).

Triploid grass carp have potential to control aquatic vegetation in large water bodies (Allen and Wattendorf 1987). However, their use must not result in overstocking or understocking (Kirk 1992). Basic biological data are needed to refine parameters used in the stocking model in order to achieve appropriate stocking densities. Our future estimates of mortality, growth, and biomass should improve stocking strategies and allow managers to more accurately predict reductions in aquatic vegetation.

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