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Collection techniques and growth of triploid grass carp in the Santee-Cooper System, South Carolina

by

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The Santee-Cooper system in South Carolina includes almost 70,000 hectares of impounded water consisting of Lake Marion, Lake Moultrie, and the diversion canal connecting the two lakes. During the last decade, hydrilla (*Hydrilla verticillata*) became established throughout the

upper reaches of Lake Marion (Inabinet 1985). The extent of hydrilla was such that chemical control became impractical.

Starting in 1989, triploid grass carp *Ctenopharyngodon idella* were stocked as a biological control agent. The stocking rates were 100,000 per year through 1992

with a goal of achieving a stocking density of approximately 50 fish per vegetated hectare. Triploid grass carp, legal for use in South Carolina since 1985, were chosen because of feeding habits similar to diploid grass carp (Wattendorf and Anderson 1984, Sutton 1985, and Allen and Wattendorf 1987), they are sterile, and they are less costly and provide longer control than herbicides.

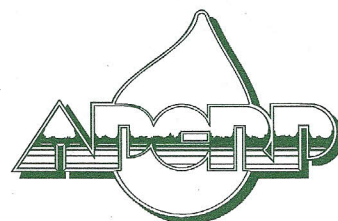
This article summarizes a grass carp collection technique, length-to-weight relationships of grass carp, information on age distribution, and rates of growth. The information on growth rates will eventually be used to update the grass carp stocking model developed at the U.S. Army Engineer Waterways Experiment Station.

Collection techniques

An initial problem in this research 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 gillnet, cove rotenone, and electrofishing sampling of the



Boat with generator-powered lights used for bowfishing





Collecting grass carp

Santee-Cooper system. Although some grass carp were collected by each of these methods, the numbers collected were inadequate for research needs.

Many 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. The most successful team was guaranteed payment of \$500 for their efforts even if they failed to collect grass carp. If successful, they would be paid \$25 per fish until approximately 70 fish were collected.

The bowfishermen hired by SCWMRD were successful in collecting 69 triploid grass carp. The collection efforts took place at night using a boat with five lights powered by a small gasoline-powered generator. The first five attempts to collect fish were unsuccessful, but successful techniques were developed. Bowfishermen stood on the bow and moved 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 2 meters. Once a fish 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. The element of skill proved to be important; the other, less skilled teams of bowfishermen were unable to collect even a single grass carp.

Length-to-weight relationships

Length-to-weight relationships are used to indicate the condition or "plumpness" of a fish population. Another use is to predict weights of fish of a given length determined by backcalculations using scales or otoliths (ear bones). Total lengths to the nearest millimeter and weights to the nearest gram were collected on 87 triploid grass carp. Eighteen measurements were taken on triploid grass carp as they were stocked into Lake Marion in April 1989, and 69

fish were collected by bowfishermen in April and May 1992.

The length-to-weight relationship was computed using a power function (Ricker 1975):

$$\text{weight} = \text{intercept} \times \text{length}^{\text{slope}}$$

The relationship was determined by regressing the log (base 10) of the weight as the dependent variable against the log (base 10) of the length as the independent variable.

The relationship that was derived was:

$$\text{weight} = 0.0000027 \times \text{length}^{3.25}$$

The coefficient of determination (r^2) was 0.99 and indicated a reasonably good fit for a length-to-weight relationship (Figure 1).

Age and growth

Generally ages are determined for fish by examining annual marks on scales, otoliths, or other bony structures. An extensive review of the literature failed to produce usable information dealing with techniques to determine ages of grass carp using otoliths or length-to-weight relationships in North American reservoirs.

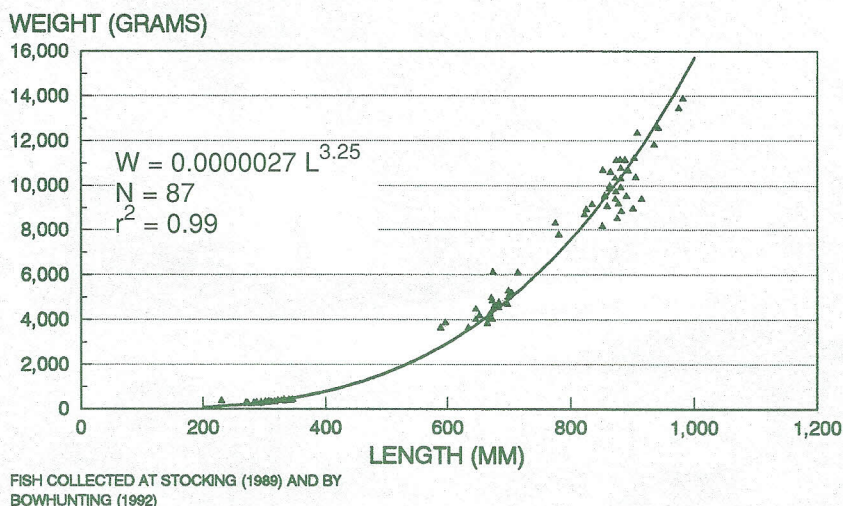


Figure 1. Length-to-weight relationship for triploid grass carp in the Santee-Cooper system

During spring and summer 1991, attempts were made to determine the ages of grass carp collected in gill nets and rotenone samples from Lake Marion, South Carolina, and Lake Guntersville, Alabama, respectively. Whole and sectioned otoliths were examined but no annuli were distinguishable. Victor (1982) stated that sagittal otoliths were unsuitable for determining age in cyprinids (the same family as the grass carp) but that the utricular otoliths could be used. This pair of otoliths is quite small and difficult to locate, even in larger grass carp. Researchers are studying the anatomy of grass carp so that utricular otoliths can be readily located. Future research efforts will attempt to validate annuli by examining structures of known age fish, examining daily growth rings on otoliths, and by comparing otolith annuli to marks on different structures.

Age and growth information presented in this article was obtained by examining scales. The scales appeared to have consistently recognizable annuli except for two samples that contained only regenerated scales. Scales 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 was 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 formula:

$$L_i = a + (L_c - a/S_c) S_i$$

where

L_i = calculated length at age i

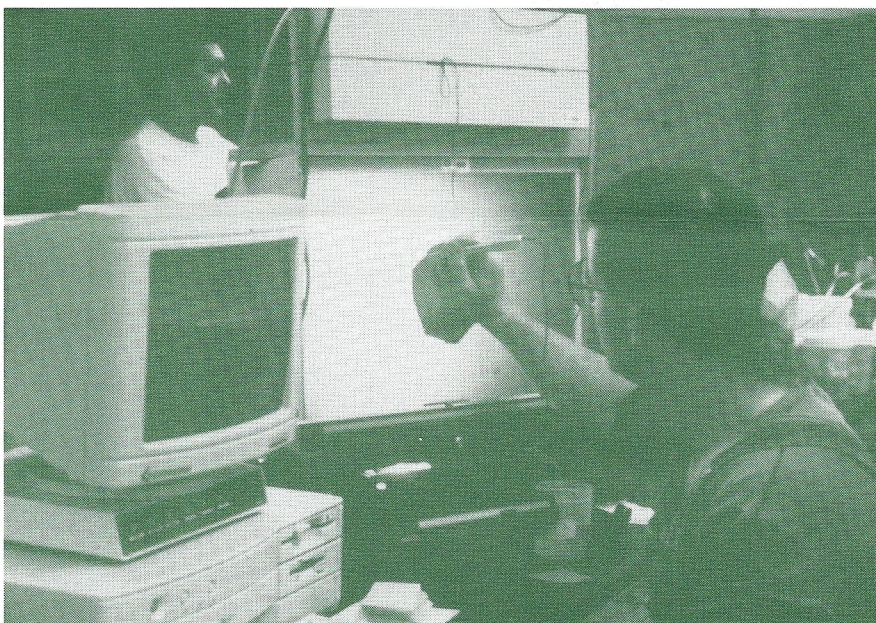
a = intercept of the body scale regression

S_c = diameter or radius of scale at capture

L_c = length of the fish at capture



Triploid grass carp scale projected on microfiche reader



Use of digitizer, microfiche projector, and computer for backcalculations using triploid grass carp scales

S_i = scale measurement at annulus i

The greatest growth of triploid grass carp collected in the Santee-Cooper system in 1992 was from age 1 to 2 years where fish grew from an average of 574 to 4,894 grams (Figure 2). From age 2 to age 3, growth was still substantial, to an average weight of 8,294

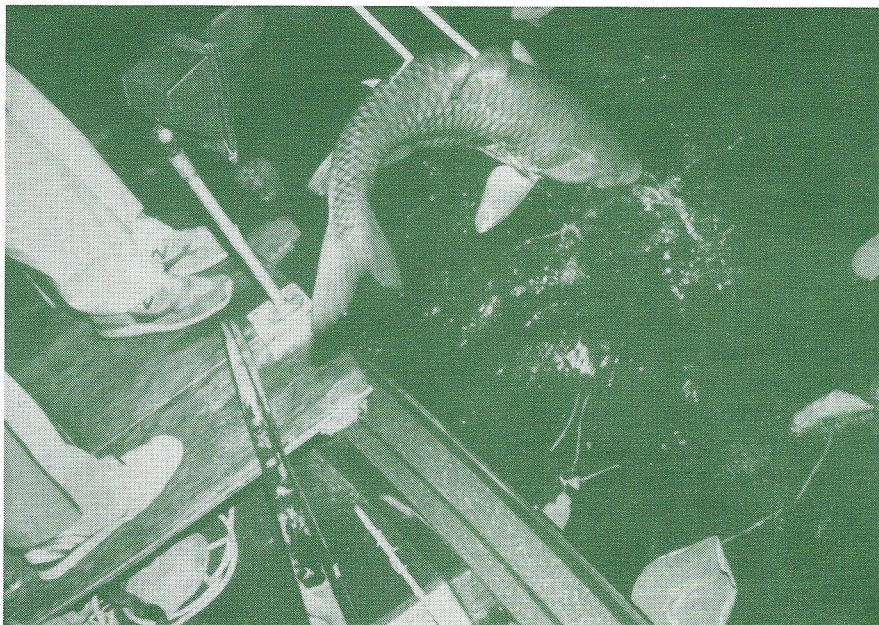
grams, but growth in length was less, about 123 millimeters.

Growth in length from age 3 to age 4 was approximately 87 millimeters, but the growth in weight was approximately the same as ages 2 to 3. The instantaneous rates of growth, G (Ricker 1975), were 2.143, 0.528, and 0.328 for ages 1-2, 2-3, and 3-4 years, respectively.

Age 4 fish were those stocked in 1989 at age 1. Most of the triploid grass carp were ages 2 or 3 and no fish stocked in 1992 at age 1 were collected. The sample was inadequate to generate age-specific mortality estimates, although oxygen depletions associated with Hurricane Hugo in 1989 may account for the lack of age 4 fish.

Summary

Skilled bowfishermen proved to be an efficient and cost-effective technique for collecting triploid grass carp when electrofishing and other collection techniques failed. Sixty-nine triploid grass carp in the Santee-Cooper system, South Carolina, were collected during April and May 1992. A length-to-weight relationship was developed from



Grass carp usually need to be shot twice for collection

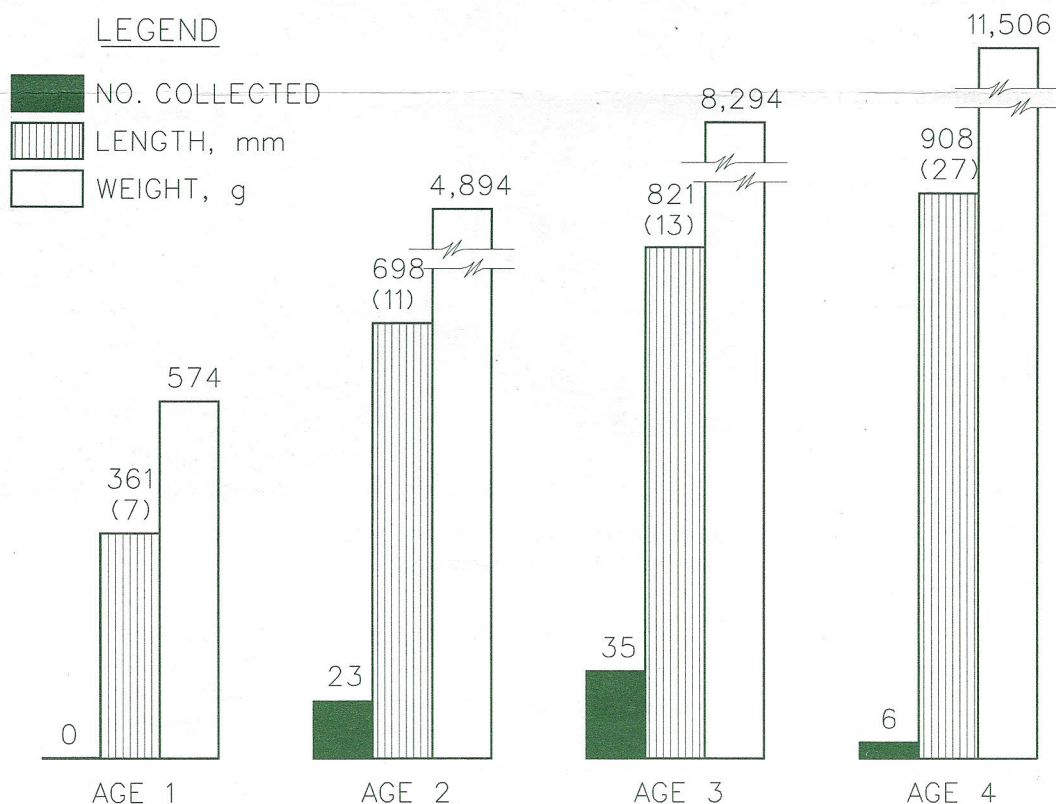


Figure 2. Age-specific lengths and weights for triploid grass carp collected in 1992 from the Santee-Cooper system using scales and backcalculation (standard errors for length are given in parentheses)

fish collected by bowfishermen and fish measured at initial stocking. Scales appeared to have consistently recognizable annuli allowing backcalculation of length at age. Triploid grass carp grew about 4 kilograms per year in the years after stocking. Ongoing research efforts will attempt to locate new aging structures and validate the use of scales.

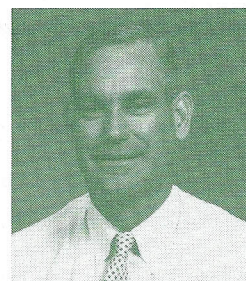
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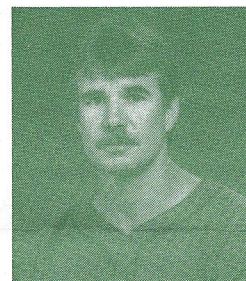
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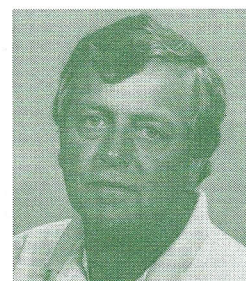
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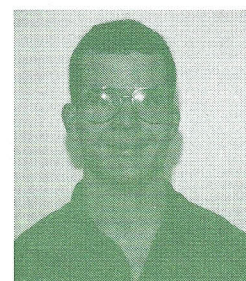
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Triploid grass carp were stocked in 1989 in the Santee-Cooper System, South Carolina, as a biological control agent for hydrilla. Traditional sampling techniques for triploid grass carp did not produce enough numbers for research purposes. This article reports on the use of bowhunting as a collection technique.



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