Stocking augmentation and growth dynamics of redear sunfish *Lepomis microlophus* in Stevens Creek Reservoir, South Carolina and Georgia.

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Summary

The objectives of this effort were to evaluate the effectiveness of stocking and learn about the redear sunfish *Lepomis microlophus* population in Stevens Creek reservoir. A three month angler survey showed that largemouth bass *Micropterus salmoides* and sunfish are the primary species sought by anglers; the reservoir is almost exclusively a 'local' fishery. Stocking was successfully performed in the fall of 2006 and 2007. Electrofishing evaluations the following year showed that stocked fish were making a substantial contribution to the stocked cohort. Growth data showed that hatchery fish were larger than wild fish. In the future, stocking appears to be a good management tool for this reservoir, however, continued evaluation of possible effects on the wild spawn is warranted.

Introduction

The redear sunfish *Lepomis microlophus* is a popular sport species in South Carolina. Compared to other sunfish commonly encountered in South Carolina, bluegill *L. macrochirus* and redbreast sunfish *L. auritus,* the redear sunfish has the largest size potential, commonly exceeding 1 kg. In fact, the current International Game Fish Association all-tackle world record for redear sunfish (2.48 kg) was caught in South Carolina.

Water level fluctuations in reservoirs can negatively affect spawning success of sunfish by exposing nests or destabilizing the shallow water environment. Like other sunfishes, the redear sunfish spawn their eggs into a nest, generally in shallow (i.e. < 2 m in depth) waters (Rohde et al 2009). Spawning generally occurs from late spring to early summer. Clark et al. (2008) showed that the predicted egg-to-dispersal survival of white crappie *Pomoxis annularis* and smallmouth bass *Micropterus dolomieu*, also nest builders from the sunfish family, declined with increasing amplitude of water level fluctuation; highest survival was always predicted for

the no-water-level-fluctuation condition.

Stevens Creek reservoir is a 970 hectare impoundment located on the Savannah River, just upstream of Savannah Georgia. The reservoir was first impounded in 1912 for the sole purpose of generating electricity. The Stevens Creek facility now operates as a re-regulating facility to mitigate the effects of highly variable discharges from the upstream, J. Strom Thurmond dam. Normal daily water level fluctuation in Stevens Creek reservoir is from 0.7 to 1.4 meters. Concern existed that fluctuating water levels may negatively affect the spawning success of nest-building fishes, such as redear sunfish.

Stocking of sunfish in small ponds is an often-used fishery management tool. However, stocking sunfish to augment population size in a relatively large impoundment, such as Stevens Creek Reservoir, has received surprisingly little evaluation. The overall of objective of this work was to evaluate the potential for augmenting redear sunfish in Stevens Creek.

The objectives of this study were:

1. Stock substantial numbers of oxytetracycline-marked redear sunfish into Stevens Creek reservoir in 2006 and 2007
2. Evaluate the contribution of hatchery-reared redear sunfish to the age-1 cohort in boat electrofishing samples collected during fall of 2007 and 2008.
3. Describe the population structure and growth of redear sunfish.
4. Conduct a 12-week creel survey in April-June, 2009, to assess angler use of Stevens Creek reservoir.

Note: Stevens Creek reservoir was defined as the waters downstream from the Highway 28 bridge downstream to Stevens Creek dam. Except for an initial survey in 2006, all stocking, sampling, and census efforts occurred in this area.

Materials and Methods

Stocking

In 2006 and 2007, redear sunfish were spawned at South Carolina Department of Natural Resources (SCDNR) hatcheries, grown-out in ponds, and stocked in the fall, approximately 6 months after spawning. Two stocking sites were used – the Fury Ferry landing just downstream of highway 28 on the South Carolina side and the South Carolina Electric and Gas landing just upstream of the dam on the Georgia side of the reservoir. Fish were transported to one of the two stocking sites in oxygenated hauling tanks. At the landing, fish were tempered until water temperature in the hauling tank was within 1° C of the Stevens Creek reservoir water temperature. Fish were then transferred to an oxygenated hauling tank in a boat and were transported to and stocked at various beds of vegetation within the reservoir. Stocking sites were recorded and an attempt was made to evenly spread the stocked fish throughout the reservoir. A sample of the stocked fish were obtained from each hauling truck prior to stocking, placed on ice, and measured (total length (TL) and weight) within 24 hours

Marking with oxytetracycline

Redear sunfish were marked with oxytetracycline (OTC) prior to stocking. Fish were immersed in OTC at concentrations ranging from 500 to 700 mg/L. The marking solution was buffered with Tris to reduce acidity associated with OTC and provide an effective pH for marking.

In 2006, samples of fish from the various marking treatments were held for grow-out at either Eastover Research Lab or Styx Fish Hatchery. At a later time, these fish were sacrificed and the otoliths were removed. The otoliths were inspected under a fluorescent compound scope by two separate readers to confirm or reject the presence of a good OTC mark. In 2007, after

OTC immersion and prior to stocking, a sub-sample of each marking batch was coded wire tagged (CWT) and re-stocked into a grow-out pond. At a later time, these fish were harvested and the coded wire tags were inspected under a microscope to determine the location, date, and batch of the OTC marking. Then, a random stratified sub-sample of 33 otoliths from the CWT, OTC-marked fish was independently inspected under a microscope by two readers for the presence of an OTC mark. These samples were mixed into the otolith samples from electrofishing samples of redear sunfish from Stevens Creek so that the readers had no prior knowledge that these fish were marked with OTC.

Electrofishing recapture sampling

During the fall of 2006, 2007, and 2008, boat electrofishing was conducted to assess the redear sunfish population in Stevens Creek Reservoir. In 2006, sampling was conducted from Steven's Creek dam upstream to Lake Thurmond dam by SCDNR and the U.S. Army Corps of Engineers. The objective of this initial sampling was to characterize general population characteristics prior to stocking.

In 2007 and 2008, electrofishing was conducted from Stevens Creek dam upstream to the highway 28 bridge crossing. Each year, sampling was conducted at locations throughout this area, attempting to cover sites representative of the entire sampling zone. The sampling zone was divided into an upper and lower sampling zone; the dividing line between zones was located at 33.58144 N, -82.09484 W (on the southern bank of the reservoir) to a point due north on the northern shoreline; an attempt was made to collect a representative sample of fish from each zone during 2007 and 2008.

Collected redear sunfish were measured (total length (TL), mm) and weighed (g). Otoliths were removed for later determination of age. Number of annuli was determined by two,

trained, independent readers. Percent agreement between readers was determined. Only those fish for which age was agreed upon by both readers were used in further analysis of growth and length at age. Mean length at age was determined for the composite 2006-2008 sample. A T-test with equal variances was used to evaluate differences in average total length of hatchery and wild redear sunfish with one annulus from the fall 2007 electrofishing collection. In 2008, the same procedure was used to compare average total length of hatchery and 'all other' redear sunfish with one annulus from the fall 2008 electrofishing collection.

A length weight regression was determined for all redear sunfish collected in 2006-2008. A length frequency distribution was calculated separately for fish collected in 2006, 2007, and 2008; each fish length was put into the nearest 2.54 cm grouping, or nearest inch group, to create usable categories.

Angler survey

From April 3, 2009 to June 25, 2009, an angler survey was conducted. This time period was broken up into three, 28 day periods, each containing 20 weekdays and 8 weekend days. Each day was divided into two, six hour survey periods, 7 AM to 1 PM and 1 PM to 7 PM. During each 28 day period, 6 weekend and 7 weekday half-day sampling periods were randomly selected. Within the survey period, an instantaneous count of bank and boat angler use was made at a randomly selected time. During the remainder of the survey period, creel clerks interviewed anglers, determining hours fished, angler catch by species, and asking questions about the angler's assessment of the fishery and where they resided .Survey results were analyzed and expanded by the University of South Carolina statistics lab according to the methods of Malvestuto (1996).

Results

A total of 148,111 and 99,491 redear sunfish were stocked during the fall of 2006 and 2007, respectively (Table 1). Weighted mean size was 76.1 mm and 6.7 g in 2006 and 100.9 mm and 18.2 g in 2007. In 2007, fish produced at the Heath Springs hatchery had a mean size of 125.9 mm and 38.7 g demonstrating the potential for raising near catchable size redear sunfish in one growing season.

Table 1. Number and average size of redear sunfish stocked into Stevens Creek Reservoir in 2006 and 2007.

Date	Stocking site	Number stocked	Mean total length, mm, (standard error)	Mean weight, grams, (standard error)	Sample size
10/12/2006	Fury's Ferry	8,300	-	-	-
10/24/2006	Fury's Ferry	41,500	73.8 (0.9)	6.2 (0.2)	60
11/7/2006	SCE&G	64,800	75.1 (0.9)	6.4 (0.2)	61
11/14/2006	Fury's Ferry	34,211	80.6 (1.5)	7.8 (0.5)	47
10/24/2007	Fury's Ferry	22,710	97.9 (0.6)	13.8 (0.3)	153
10/31/2007	SCE&G	21,835	93.7 (0.9)	12.8 (0.6)	107
11/6/2007	SCE&G	5,744	142.5 (2.9)	61.6 (3.9)	21
11/7/2007	Fury's Ferry	13,682	118.9 (1.4)	29.1 (1.3)	84
11/12/2007	SCE&G	17,520	97.4 (0.8)	15.0 (0.4)	111
11/16/2007	Fury's Ferry	18,000	89.8 (1.2)	11.3 (1.0)	53

In 2006, redear sunfish were successfully marked with OTC. Difficulty was experienced growing out the fish to a size where the mark was distinct from the edge of the otolith. On April 23, 2007, 20 otoliths from fish that were grown-out at Eastover from the October 12, 2006 stocking were inspected for marks; total length of the fish at that time ranged from 79 to 113 mm. OTC marks were clearly present near the edge of the otolith on the five largest fish (103-113 mm, TL); marks were not clearly visible on the other fish (79 to 99 mm TL). It was hypothesized that growth was not adequate in the smaller fish to observe the OTC mark.

Subsequently, in May, 2007, otoliths from fish > 100 mm TL were inspected for an OTC mark; fish came from the 10/24/07 (N=5), 11/7/07 (N=3), and 11/14 (N=1) stocking. Both readers judged that all otoliths were clearly marked with OTC, though the marks were still very close to the edge. A third sample of fish were grown out from the 11/14/06 stocking to 6/4/07 and ranged in size from 81 to 121 mm TL. Both readers saw clear marks in all inspected fish (N=9).

In 2007, marking success was inconsistent. Of 32 known-marked fish that were inspected only 10 (31%) were identified as 'marked' by both readers. Some marking dates produced higher percentages of successfully marked fish than other dates (Table 2). Weighting percentage marked for a stocking date by the total number stocked on a stocking date, produced an estimate that 29 % of redear sunfish stocked in 2007 were clearly marked.

Table 2. Oxytetracycline mark identification by two independent reads of marked redear sunfish.

			Number	
Date (2007)	Hatchery	Inspected	Both = 'marked'	One = 'marked'
10/23	Cheraw	7	6	0
10/30	Cheraw	4	0	0
11/5	Spring Stevens	5	0	1
11/6	Spring Stevens	7	1	0
11/15	Cheraw	2	0	1
11/15	Cohen Campbell	7	3	1
Total		32	10	3

A total of 760 redear sunfish were collected by electrofishing during the 2006-2008. The relation between total length and weight was defined as:

Log10 weight (g) = -4.94 + 3.11 * log10 total length (mm); R^2 = 0.99; N = 760.

A total of 723 fish had otoliths that could be aged by both independent readers; age agreement between both readers occurred for 612 (85%) fish. Mean length was calculated for these fall-collected fish (Table 3) and, for 2006-2008, was 130 , 171, and 203 mm for redear sunfish with

1, 2, and 3 annuli, respectively; length at age was similar among years. Of note, a fish with 18 annuli was collected in 2006.

Table 3. Mean length at age for redear sunfish from Stevens Creek Reservoir, 2006-2008. Fish were collected in fall, so there was considerable growth beyond the last annulus.

Year	Annuli	N	Mean Total Length (mm)	Standard Deviation
	1	10	124	28
	2	49	171	25
	3	11	192	28
2006	4	8	235	40
	5	3	263	5
	6	2	248	59
	8	1	305	NA
	18	1	318	NA
	1	153	128	24
	2	58	169	27
	3	16	202	17
2007	4	6	210	33
	5	3	244	6
	6	2	285	7
	8	1	313	NA
	0	13	85	13
	1	147	133	29
	2	90	172	28
2008	3	27	208	16
	4	8	216	25
	5	3	210	45

Approximately one year from stocking, results strongly suggested that hatchery fish were significantly larger than wild fish. In fall of 2007 collections of redear sunfish with one annulus, hatchery fish were significantly ($P < 0.001$) longer than wild fish; hatchery and wild fish averaged 137 (N=72) and 117 (N=70) mm TL, respectively. Since we could not clearly differentiate hatchery from wild fish from the fall 2007 stocking, we compared hatchery fish (i.e. both readers saw an oxytetracycline mark) with 'all other' fish. In fall of 2008 collections of

redear sunfish with one annulus, hatchery fish were significantly ($P < 0.001$) longer than 'all other' fish; hatchery and 'all other' averaged 167 (N=13) and 129 (N=134) mm TL, respectively. In 2006, prior to stocking, redear sunfish with one annulus averaged 124 mm TL (N=10; 95% confidence interval = ± 17 mm).

Length-frequency histograms were prepared for the three study years (Figure 1) and modes generally agreed with average length at age. However, 2008 length-frequency showed a modal size for fish with one annulus that was lower than the average size.

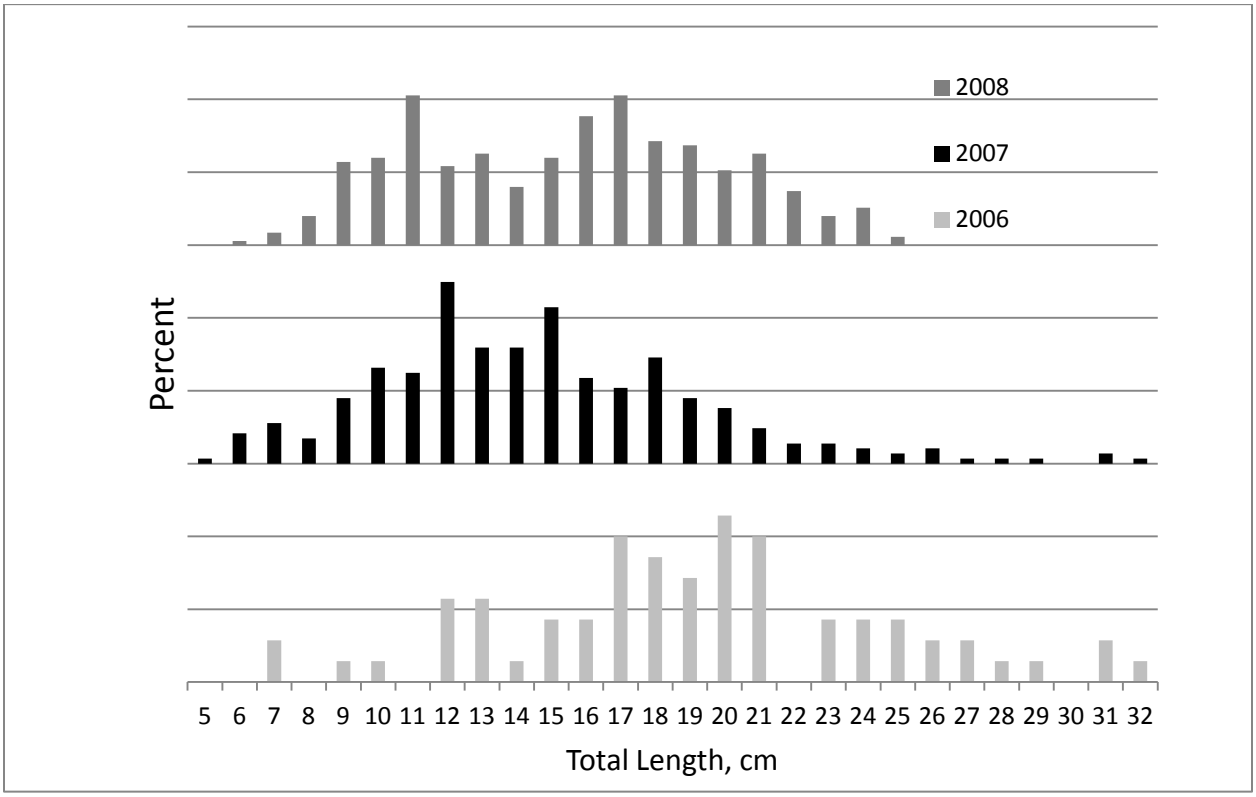

Figure 1. Length frequency histogram of redear sunfish collected from Stevens Creek Reservoir in 2006 (N=70), 2007 (N=289), and 2008 (N=351). Each horizontal gridline represents 5% of the total catch for each year.

In 2007, 147 redear sunfish otoliths with one annulus were inspected for the oxytetracycline mark associated with the fall 2006 stocking. In four instances, the two readers disagreed upon whether a mark was visible. For the remaining otoliths, 72 (50%) were marked

and 71 were not marked. One otolith reader blindly read a subsample of otoliths a second time; the reader agreed with his initial interpretation of 72 of 80 (90%) otoliths.

In 2008, 70 redear sunfish otoliths with one annulus were inspected for the oxytetracycline mark associated with the fall 2007 stocking. In eight instances, the two readers disagreed upon whether a mark was visible. For the remaining otoliths, 13 (21%) were marked and 49 were not marked.

Angler Survey

During the 84-day survey period, anglers fished for 3,242 (relative standard error (RSE) = 14.9) hours, which, on average, breaks down to approximately 39 hours of angler effort per day. Boat angling accounted for 93% of effort. Anglers harvested an estimated 2,834 (RSE = 30.2) fish; anglers released 2,378 fish (RSE 30.9).

The estimated catch rate (harvested and released fish) was 1.6 fish/hour (RSE = 21.2). Expansion of surveys revealed that the catch was dominated by bluegill (N=1,772; RSE = 214), largemouth bass (N=873; RSE=246), redear sunfish (N=644; RSE=363), and redbreast sunfish (N=563; RSE=627), though variance associated with these estimates too high to be deemed reliable estimates.

Bluegill dominated the fish directly observed as harvested by the clerks. Of those observed fish, bluegill was 54%, redbreast sunfish 18%, largemouth bass 14%, and redear sunfish comprised 11%.

Intended fishing effort, based on the target species identified by the angler, indicated that largemouth bass and sunfish were the most sought after species. Interviews indicated that 36% sought largemouth bass, 25% sought “bream” (i.e. any of the sunfish species), 15% sought redear sunfish, and 15% sought ‘anything;’ all other categories were less than 5% of intended effort.

Anglers were local (within 50 miles) in origin. Most came from GA (63%) and the remainder from SC. These anglers (N=27) classified the fishery as excellent (11%), good (59%), fair (26%), and poor (4%).

Discussion

A 3-month angler survey showed that Stevens Creek was a local fishery where anglers were primarily targeting largemouth bass and sunfish. Angling pressure was light to moderate while the majority of anglers classified the fishery as 'good.' This study was not designed to show whether the fishery was enhanced, in terms of effort and catch rate, due to the stocking. However, the stocking did appear to positively augment the redear sunfish fishery, which would likely result in increased effort and greater success by anglers.

Hatchery stocking made a substantial contribution to the redear sunfish population of Stevens Creek reservoir. The 2006 stocking accounted for 50% of redear sunfish with one annulus collected during the fall of 2007. The 2007 stocking could not be evaluated as effectively as only 31% of the known-marked fish were successfully identified. However, even with this limitation, 21% of the fish with one annulus collected in 2008 were identified as hatchery fish by both otolith readers. If we assume that only 31% of the hatchery fish were successfully identified, then the actual percentage of hatchery fish would have been much greater.

Length comparisons of redear sunfish with one annulus showed that hatchery-stocked fish were larger than wild fish. In 2006, prior to stocking, wild fish averaged 124 mm TL. Hatchery fish from the 2006 stocking were, on average, 20 mm longer than wild fish in the fall of 2007 collections. Identifiable hatchery fish from the 2007 stocking were, on average, 38 mm longer in the fall 2008 collections than 'all other' fish, which was an unknown mix of wild and

unidentified hatchery fish. The larger size of hatchery fish from the 2007 stocking appears to relate to size at stocking; in 2006 and 2007, fish averaged 76 and 101 mm TL at stocking, respectively.

It appears that stocked fish had a size advantage on wild fish at stocking, which was maintained approximately one year after stocking. Unfortunately, this study did not produce a reliable estimate of size of age-0 wild fish at stocking, as the electrofishing gear was not an effective sampling gear for these fish. This size advantage may allow stocked fish to escape a food bottleneck earlier than wild fish, allowing them to recruit faster to the sport fishery. An earlier preliminary study with a high school intern showed that Stevens Creek redear sunfish switched from plankton/insects to snails at approximately 150 mm TL. Thus, from a management perspective, stocking of redear sunfish appears to augment a year class and produce fish that will recruit more quickly to the sport fishery. However, this study did not have adequate information to discern whether hatchery fish were limiting the abundance or growth of wild-spawned fish. Future studies must obtain additional measures of the abundance and size at age-0 to evaluate this.

Recommendations

If the economics of the fishery warrant, develop and implement a long-term redear sunfish stocking and monitoring plan on Stevens Creek reservoir. Based on the information obtained in this study, the stocking/monitoring plan should have the following characteristics:

- Mark all stocked fish
- Use the stocking rate, method of stocking, and size of stocked fish that was used in 2008, as larger stocked fish seem to have advantages for the fishery and for the redear sunfish population

- Develop a sampling method of capable of estimating the average size of age-0 redear sunfish during late September or early October, prior to stocking; this is needed to compare size of hatchery fish to size of wild fish.
- Implement a stocking plan where stocking occurs for 3 consecutive years followed by 3 consecutive years of non-stocking to better evaluate the effects of stocking.
- Implement a recapture sampling method in the fall that has fixed stations and effort so that catch per unit of effort can be used an index of abundance; take into account reservoir stage fluctuations, which can affect sampling efficiency.
- Consider enlisting local anglers to help monitor the fishery.

Literature Cited

Clark, M. and 5 co-authors. 2008. Water-level fluctuation effects on centrachid reproductive success in reservoirs: a modeling analysis. North American Journal of Fisheries Management 28:1138-1156.

Malvestuto, S.P. 1996. Sampling the recreational creel. *In* B. Murphy and D. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Rohde, F. and 3 co-authors. 2009. Freshwater Fishes of South Carolina. University of South Carolina Press, Columbia, South Carolina.

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