Evidence of Striped Bass Spawning in the Upper Coosa River Basin, Georgia

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Abstract: Striped bass have been stocked into the Upper Coosa River Basin (Alabama and Georgia) since the 1970s. The increased presence of small striped bass within these waters in recent years suggested the possibility of a resident spawning population. Ichthyoplankton samples were collected once or twice per week from April to June 1997 and 1998 from sample sites in the tributaries of the Coosa River above Weiss Reservoir. Fertilized striped bass eggs were collected from the Oostanaula River during both years and the Conasauga River in 1998 (the only year sampled). The peak spawning activity for both years occurred in mid-May, when the water temperature reached approximately 18 C. The peak density was lower in 1997 than in 1998, at 4.7 and 77.1 eggs/m^3, respectively. The majority of the eggs collected were spawned less than 20 hours prior to harvest, indicating that much of the spawning was occurring within 76 km of Weiss Reservoir.

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Striped bass *(Morone saxatilis)* are native to the Mobile River and lower Alabama-Coosa-Tallapoosa (ACT) River Basin (Swingle 1969); however, their presence in the Upper Coosa River Basin (UCRB) above Weiss Reservoir is due to repeated stockings. The stocking of striped bass in this region of the UCRB began in 1973 when the Georgia Department of Natural Resources (GADNR) stocked 25,000 striped bass (age-0) in Allatoona Reservoir (GADNR 1998). Since that time, more than 1.1 million ($\bar{x}$=56,000/year, N=20) fry and/or fingerling striped bass have been stocked in Allatoona, 167,000 ($\bar{x}$=18,600/year, N=9) in Carters Reservoir, 3.8 million

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($\bar{x}$=960,000/year N=4) in the Coosa River (GADNR 1998), and 89,700 ($\bar{x}$=26,000/year N=5) in Weiss Reservoir (Catchings and Smith 1994). It was generally believed that these stockings contributed to the continued occurrence of striped bass in the Upper Coosa Basin. However, anglers began reporting an increased sighting of small striped bass in the Coosa, Oostanaula, and Etowah Rivers. The sheer number of small striped bass suggested the possibility of some natural reproduction occurring within the watershed. The potential spawning area for striped bass in the UCRB would then include the Coosa River, above Weiss Reservoir, and its 2 major tributaries.

The Coosa River, formed by the confluence of the Oostanaula and Etowah Rivers, extends 50 km upstream of Weiss Reservoir (Fig. 1). The headwater of the Etowah River is near Atlanta and the Oostanaula River (76 km) is formed near Calhoun, Georgia, at the confluence of the Coosawattee and the Conasauga Rivers (146 km). Upstream movement of migratory fishes in both the Etowah (75 km) and Coosawatee (40 km) rivers is currently blocked prior to the headwaters by Allatoona Dam and Carters Dam, respectively.

Little information exists about the population of striped bass in the Upper Coosa River Basin. While striped bass of various size classes are frequently caught by recreational anglers, their origin is unknown. Stockings in Allatoona Reservoir and Carters Lake are upstream of the target area, so escapement into downstream waters might be significant. In one study, Heidinger et al. (1984) reported that 21% of the harvested striped bass came from below the spillway of the receiving waters. Downstream movement of striped bass can be great. Bishop (1968) found striped bass stocked into Watts Bar Reservoir had moved 524 km downstream, which had required passage over or through 5 dams. The purpose of this study was to verify spawning activity of landlocked striped bass and to identify the general spawning area in the UCRB.

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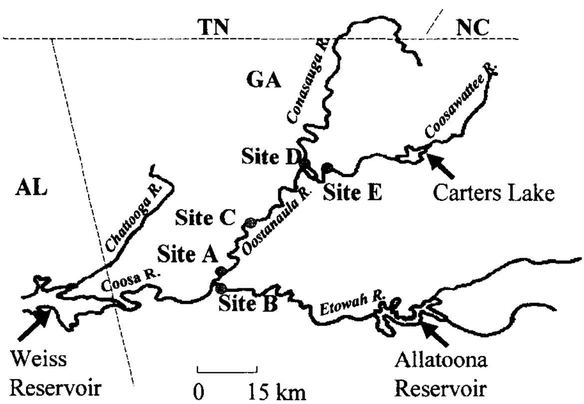

Figure 1. Upper Coosa River Basin and sample sites.

Methods

Sampling for striped bass eggs was carried out at a number of sites (Fig. 1) during the 1997 and 1998 spawning seasons. During 1997, samples were collected at 2 sites: one was 0.5 km upstream from the mouth on the Oostanaula River (Site A) and the other was 0.5 km upstream of the mouth of the Etowah River (Site B). These sites were sampled once per week from 10 April through 1 June 1997. Based on the presence of striped bass eggs from Site A in 1997, we decided to add 3 additional sites within the Oostanaula system in 1998 in hopes of more accurately locating the spawn areas. Site C (Hwy. 140 bridge) was located on the Oostanaula River, 19.5 km upstream from the mouth. The other 2 sites were 0.5 km upstream from the start of the Oostanaula River in the Conasauga (Site D) and Coosawattee rivers (Site E) (Fig. 1). The 2 headwater sites were sampled on a weekly basis during May 1998, while the lower 3 sites were sampled approximately twice per week throughout the spawning season.

Egg collections were made with the use of a 0.25-m diameter plankton net in 1997 and a 0.5-m diameter net in 1998. Both nets had a 5:1 surface area to opening ratio and 0.75-mm mesh. The net was attached to a rope via a 3-point bridle and fitted with a calibrated General Oceanic (Miami, Fla.) Model 2030 flow meter to measure sample volume. An attempt was made to filter 100 m^3 of water during each collection. The net was fished from an anchored boat, mid-channel, and approximately 0.5 m below the surface. Rulifson et al. (1993) found no significant difference in the percentage of striped bass collected between the top and bottom of the water column over a 4-year period in the Roanoke River. Water quality measurements including temperature, dissolved oxygen, pH, conductivity, nitrates (1998 only), alkalinity (as $CaCO_3$), and hardness (as $CaCO_3$) were taken during each collection. Water quality measurements were taken with a YSI Model 51B meter (Yellow Springs Instrument Co., Yellow Springs, Ohio) and a Hach DREL 2000 water quality laboratory (Loveland, Colo.)

Collected samples were fixed in the field with 10% unbuffered formalin and then returned to the laboratory. Within 24 hours, the fluid in the samples was drained and replaced with 7% unbuffered formalin containing Eosin and Biebrich Scarlet stains (Klinger and Van Den Avyle 1993). The samples were later sorted with a binocular microscope. The eggs were identified to species (Bayless 1972), the diameter of the chorion and embryo measured, staged into 1 of 5 developmental categories (Bayless 1972, Gilbert et al. 1985), and then counted by category (Table 1). The developmental-stage categories used in this study were described by Gilbert et al. (1985) and are based on a water temperature of 19 C. The corresponding ages (in hours) for the developmental categories we used are S-1, 0 to 10 hours old; S-2, 10 to 19 hours old; S-3, 19 to 26 hours old; S-4, 25 to 33 hours old; and S-5, 33 to 44 hours old.

Estimates of egg density within the river locations were based on hourly discharge rates provided by the U.S. Geological Survey (USGS Water Resour., Atlanta Office, pers. commun.) for the gauging station nearest the sample site (Farley 1966, Combs 1979). Predicted spawning areas were derived from the age of the egg in hours (S-1 to S-5) and the mean daily velocity of that section of the river using hourly

Table 1. Proportion of total eggs sampled by category at Site A (1997 and 1998) and Site C (1998).

				Percentage			
Site	Date	*N* Collected	*N* Staged	S-1	S-2	S-3	S-4
1997							
A	9 May	18	7	100	0	0	0
A	14 May	520	413	69	30	1	0
A	21 May	233	206	36	54	4	5
Total		771	626	59	37	2	2
1998							
A	30 Apr	145	74	7	49	45	0
A	4 May	33	2	0	100	0	0
A	5 May	1	1	0	0	0	100
A	7 May	993	263	3	97	1	0
A	9 May	21	6	17	33	50	0
A	12 May	5,550	4,400	3	75	22	0
A	14 May	4,490	3,730	0	88	6	6
A	15 May	4,465	4,063	2	37	39	23
A	18 May	18	14	21	36	43	0
A	19 May	80	69	7	13	80	0
A	23 May	3	3	0	0	0	100
A	26 May	11	10	0	0	100	0
A	28 May	1	1	0	0	100	0
A	8 Jun	68	31	0	100	0	0
Total		15,879	12,667	2	66	23	9
C	1 May	19	6	0	67	33	0
C	11 May	2,099	1,514	8	78	73	2
C	12 May	1,982	1,302	3	94	2	2
C	15 May	721	565	0	3	97	10
C	18 May	9	2	0	0	100	0
C	19 May	22	0	0	0	0	0
C	21 May	22	16	0	31	69	0
Total		4,874	3,405	4	45	48	3

USGS discharge data converted to velocity (USGS Water Resour., Atlanta Office, pers. commun.). The developmental progress was temperature corrected (Bohnsack and Zale 1992) using the equation $D_e = 10.77e^{-0.0934T}$ where D_e=days to hatch and T=temperature in °C (Rogers et al. 1977). By converting D_e to hours, a correction factor was obtained to adjust developmental time for temperatures other than 19 C. Computation of egg transport distance from the spawning site(s) employed a drift rate of 80% of the water velocity (Neal 1971).

Results

Striped bass spawning occurred in the UCRB, primarily within the Oostanaula River during 1997 and 1998. The greatest number of eggs was collected in mid-May

(Fig. 2), when the water temperature reached 17.7 and 18.5 C in 1997 and 1998, respectively. The peak measured density in 1997 was 4.7 eggs/m^3 on 14 May and 77.1 eggs/m^3 on 12 May 1998. Spawning lasted at least 13 days in 1997 and 40 days in 1998. Striped bass eggs were not collected from the Etowah River during either sample year, nor were any eggs collected from the Coosawattee River in 1998 (the only year sampled).

In 1997, eggs were first collected from Site A on 9 May at a water temperature of 18 C. The river discharge had dropped from a peak on 4 May of 702 m^3/sec to 206 m^3/sec (Fig. 2). Spawning activity in 1998 also was primarily restricted to the Oostanaula River, while lower concentrations of eggs were collected from Site D, near the mouth of the Conasauga River. Site A yielded the greatest concentration of striped bass eggs over the longest period of time. Eggs were first collected as the water temperature reached 15 C (Fig. 2) and regularly collected until the water temperature reached 25 C. The greatest concentrations of eggs were collected as the water temperature rose from 18.5 to 21.5 C (Fig. 2). Eggs were collected again in June 1998, following a 3.5 C drop in water temperature; however, no additional eggs were collected after that date (Fig. 2). Eggs also were collected from Site C (Oostanaula River at Route 140) in 1998. While the density was much lower than those recovered at Site A, the general pattern was similar to the downstream site (Site A). Eggs were first collected on 1 May 1998 (15 C), and the density peaked on 12 May (18 C).

Approximately 78% of the striped bass eggs collected were stageable (Table 1). Of those that could not be stated, natural mortality and collection damage were

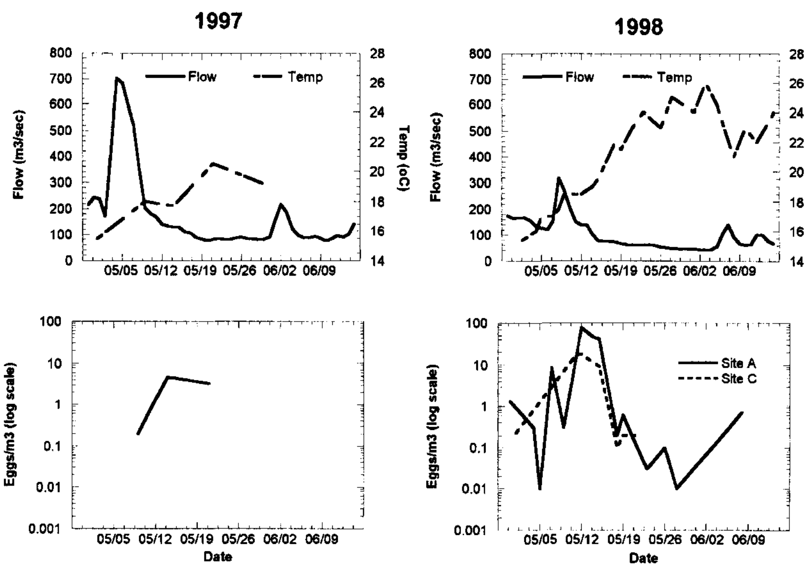

Figure 2. Daily mean flow, temperature, and egg density for the Oostanaula River during 1997 and 1998.

believed to be the primary causes. On 2 occasions, insufficient preservative added to the samples from Site A led to decay. S-2 eggs were the predominant group (61%) of the 16,698 staged eggs collected from Sites A and C in 1997 and 1998, whereas 27% were S-3 (Table 1). When the age of the eggs from these 2 sites was temperature corrected, it was determined that 92% had been fertilized less than 25 hours prior to collection and 77% less than 20 hours. Identification of specific spawning sites was not feasible, because of the wide temporal range within each category; however, some river stretches appear to have been utilized more frequently than others. During the 1997 spawning season, 65% of the eggs had drifted less than 15 hours. Thus, the majority of the spawning occurred within 26 km upstream from Site A. The remainder of the spawning activity occurred within 35 km. Based on discharges and collection densities, a range of approximately 1.7×10^5 to 2.3×10^6 striped bass eggs per hour were passing Site A in 1997.

Considerably more striped bass eggs were collected in the UCRB in 1998 than in 1997. During the peak spawning period in 1998 (12, 14, and 15 May), the majority (67%) of eggs were spawned in the same general area as in 1997 (between 14 and 29 km upstream of Site A). Secondary contributions were made inside of 14 km and as far as 36 km. The eggs collected from Site C indicate that the spawning area may extend 65 km upstream; however, most (58%) of the eggs were spawned within 43 km of the collection site. Egg densities in 1998, based on the collections from Site A, ranged from 1.8×10^3 to 3.8×10^7 eggs/hour.

Dissolved oxygen concentrations (range 6.2 to 9.1 mg/liter) in all samples remained above detrimental levels (Setzler et al. 1980) during the entire sample period. Minor fluctuations occurred between rivers in pH (range 6.8 to 7.5) and levels were near neutral. The concentration of nitrogen-nitrates was less than 1 mg/liter at all sites in 1998, except on one date at Site C (1.5 mg/liter). The watershed for both the Oostanaula and Etowah rivers is primarily forested land with the Southern Appalachian Ridges and Valley resource and is characterized by metamorphic rocks which do not provide a great deal of buffering capacity (U.S. Dep. Agric. 1978). As a result, total alkalinity and hardness were below 100 mg/liter in all samples. The greatest alkalinity and hardness levels (86.0 and 86.5, respectively) were measured in the Conasauga River (Site D). The Oostanaula River (Site A) had the lowest mean values for both total alkalinity and hardness in 1997. The mean for total alkalinity was 34.0 ± 3.5 mg/liter as $CaCO_3$ (range 28.3 to 38.5). Mean hardness was 44.0 ± 11.3 mg/liter (range 34 to 64) as $CaCO_3$.

Discussion

The presence of fertilized striped bass eggs from 3 of the 5 sites proves that the resident population in the UCRB is spawning. There was, however, a considerable difference between the 1997 and 1998 spawning seasons both in terms of duration and intensity. While there was a change in net size between 1997 and 1998 in this study, McCoy (1959) compared striped bass egg collection rates between a 0.25-m and a 1-m diameter net and found no significant difference during 5-, 10-, and 15-

minute samples. Weekly sampling in 1997 may have missed the actual peak period; however, no eggs were collected during the first 4 samples when the water temperature ranged between 16.5 and 17.5 C. Van Den Avyle and Maynard (1994) reported that spawning usually follows warming trends when water temperature was between 17 and 22 C, but eggs were still collected at temperatures as high as 24 C in the Savannah River. Evidence of spawning activity was collected over a 12-day period in 1997 and 44 days in 1998. Smith (1970) reported similar variations in the lower Savannah River over a 3-year period. He found that spawning lasted 14 days in 1968, 53 days in 1969, and 22 days in 1970. The temperatures were very similar all 3 years, ranging from 16.6 to 22.2 C over the course of the spawning season. Water temperatures varied slightly between the 2 years in this study. In 1997 spawning occurred between 18 and 20.5 C and between 15 and 25 C in 1998. Peak egg densities were collected at temperatures of 17.7 and 18.5 C in 1997 and 1998, respectively. Similar peaks at these temperatures have been reported from the Arkansas River (Bohnsack and Zale 1992), the Sacramento-San Joaquin System (Farley 1966), the Santee-Cooper System (Bulak 1994), and the Savannah River (Dudley and Black 1978). Farley (1966) found that the onset of spawning occurred when water temperatures reach 14.4 to 15 C and may temporarily cease if temperature drops back below 15.6 C. Due to the infrequency of sampling in 1997, some intermediate temperature drops may have occurred between samples.

Other biologists also have found annual variations in egg density within the same river (Bohnsack and Zale 1992, Bulak et al. 1997). Changes in water quality (Radtke and Turner 1967), temperature (Farley 1966), overharvest (Goodyear 1985), and changes in discharge (Bulak 1994, Van Den Avyle and Maynard 1994) have been implicated as causal factors of annual variation in egg production. Combs (1979) found that spawning site selection was dependent on discharge and Van Den Avyle and Maynard (1994) reported peak egg densities at flows from 170 to 340 m^3/sec, when discharge was stable or decreasing. Discharge in the Oostanaula River exceeded 340 m^3/sec from 4 May through 10 May 1997, peaking at 702 m^3/sec (Fig. 2). This high discharge during the early part of the 1997 spawning season may have been detrimental to that year's striped bass egg production. The discharge in 1998 was more stable and the peak spawn occurred on a declining discharge at 139 m^3/sec (Fig. 2).

Variations in discharge may have contributed to the lack of spawning activity in the Etowah River. Adult striped bass are known to inhabit the Etowah River, as anglers frequently report catching them, especially during the summer months. The physical and chemical characteristics are similar between the 2 rivers with a few exceptions (Davin, unpubl. data). There is no significant difference between temperature, pH, nitrates, alkalinity, and hardness. While dissolved oxygen concentrations and conductivity were found to be different between the Oostanaula (7.8 ± 0.7 mg/liter and $125.8 \pm 30.8 \mu S$) and Etowah River (8.5 ± 0.8 mg/liter and $97.7 \pm 33.1 \mu S$), both were within suitable levels for egg survival (Setzler et al. 1980). Both rivers also have similar substrate (a mixture of sand, gravel, and rock), length, and cross-sectional profile (approximately 68 m wide and 3.5 m deep at the sample sites). Discharge,

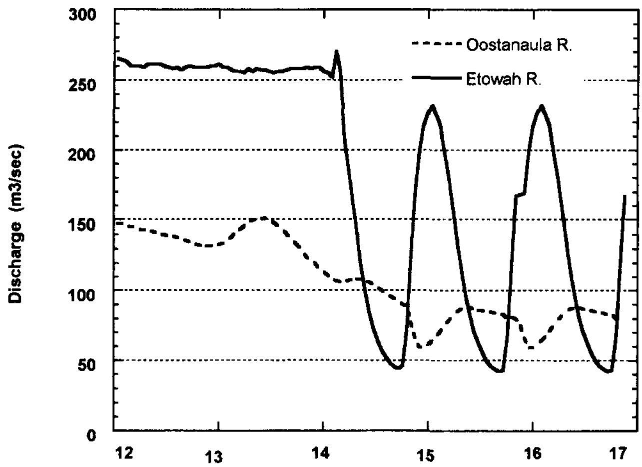

Figure 3. Hourly discharge in the Oostanaula and Etowah rivers for 12–17 May 1998.

however, is significantly different between the 2 rivers. The amount of water released into both rivers is controlled by hydroelectric peaking facilities with similar operational schedules (evening hours for 5 days each week). Carters Lake hydroelectric plant on the Coosawattee River (a tributary of the Oostanaula River) has a regulation pool below the dam while Allatoona Dam does not, instead discharging directly into the Etowah. The direct discharge during power generation periods results in hourly discharge fluctuations in the Etowah River. For example, during the peak spawning period in 1998, fluctuations of up to 200 m^3/sec occurred within a 12-hour period (Fig. 3) (USGS Water Resour., Atlanta Office, pers. commun.). Neal (1971) suggested that fluctuating flows might be deleterious to striped bass spawning and reported an increase in the number of eggs collected following the regulation of flow in the Roanoke River. Daily discharge rates and velocity measurements commonly reported for striped bass spawning areas may not be the best means by which to assess the suitability of a given river for striped bass spawning. Fisheries biologists may need to examine the variance in discharge, especially during the spawning period.

Estimation of spawning areas using developmental age and river velocity indicated that a majority of the eggs collected at Site A had drifted between 14 and 29 km. These findings would suggest that much of the spawning was occurring at or above Site C (19 km above Site A). The range of different developmental stages present in any given sample (Table 1) indicates that spawning may be occurring over long stretches of the river and not confined to any specific area.

Johnson and Koo (1975) found egg densities as high as 36 eggs/m^3 and thought that was the highest density reported to date. Since that time, densities as high as 452 eggs/m^3 have been reported from landlocked striped bass populations (Bulak et al. 1997). Our peak density of 77.1 eggs/m^3 or 38 million eggs per hour represents a major contribution to the system. However, the amount of recruitment, if any, into the ACT River Basin is unknown.

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