The Status of *Macrochelys temminckii* (Alligator Snapping Turtle) in the Flint River, GA, 22 Years after the Close of Commercial Harvest

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Abstract - *Macrochelys temminckii* (Alligator Snapping Turtle) was petitioned for federal listing as threatened under the Endangered Species Act in 2012 as a result of population declines attributable in part to harvest for human consumption. The species was listed as threatened in 1992 in Georgia, where all harvest of the species was closed. Because little is known about how Alligator Snapping Turtle populations respond to protection, we surveyed Georgia's Flint River, which had originally been surveyed in 1989, to assess whether abundance of Alligator Snapping Turtles increased following close of commercial harvest. Our survey, conducted in 2014 and 2015 yielded captures of 52 Alligator Snapping Turtles with an overall catch per unit effort (CPUE) of 0.09 turtles/trap-night, as compared to 62 captures and a CPUE of 0.08 turtles/trap-night in the 1989 survey. Although CPUE was similar between the two studies, we observed differences among the lower, middle, and upper reaches of the river; CPUE increased in the lower reach, decreased slightly in the middle reach, and remained the same in the upper reach of the Flint River. Mean size (carapace length) of Alligator Snapping Turtles did not differ between the 2 surveys, but in 2014–2015 we caught nearly twice as many immature (<40 cm carapace length) turtles as adult males and females, and the highest proportion of immature turtles was captured in the upper reach. Our findings suggest that the Alligator Snapping Turtle population in the Flint River has not increased despite 22 years of protection from commercial harvest. Recovery may be hampered by life-history characteristics of the species including delayed maturity and low reproductive output; however, we cannot rule out possible ongoing mortality of Alligator Snapping Turtles from illegal harvest or drowning on abandoned limb lines, as has been observed in other populations.

Introduction

The Alligator Snapping Turtle (Troost) (*Macrochelys temminckii*) is the largest freshwater turtle species in North America (Ernst and Lovich 2009, Pritchard 2006); males may reach a carapace length of 80 cm and weigh more than 113 kg (Lovich 1993, Teare 2010). The species occurs principally in rivers of the southeastern US and is highly aquatic, with adult females leaving the water only to nest, and hatchlings moving overland from the nest to the water (Pritchard 2006). The species is long-lived with high adult survival (Folt et al. 2016, Reed et al. 2002) and both males and females attain sexual maturity at 11–13 years of age (Dobie 1971, Pritchard 2006, Reed et al. 2002). Reproductive output is low relative to body size

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and varies greatly across the range of the species (Dobie 1971, Ernst and Lovich 2009, Ewert et al. 2006, Teare 2010).

Alligator Snapping Turtle populations declined drastically during the 1970s and 1980s, and the declines are due at least in part to commercial harvest (Pritchard 2006, Reed et al. 2002). For example, one trapper reportedly harvested 4000–5000 Alligator Snapping Turtles from the Flint River and its tributaries in Georgia from 1971–1983, with an estimated catch per unit effort (CPUE) of 1.00 turtles/trap-night on the Flint River (Johnson 1989). A survey by the same trapper in 1989 yielded captures of 62 Alligator Snapping Turtles and a CPUE of only 0.08 turtles/trap-night on the same portion of the Flint River (Johnson 1989). Additional threats to Alligator Snapping Turtles include habitat loss and degradation and mortality from bush hooks and trotlines (Folt and Godwin 2013, Howey and Dinkelacker 2013, Jensen 1999). The Alligator Snapping Turtle was state-listed as threatened in Georgia in 1992 (Jensen and Birkhead 2003). The species was petitioned for listing as threatened under the US Endangered Species Act in 2012 (Center for Biological Diversity 2012).

In an analysis of the sustainability of harvest of Alligator Snapping Turtles, Reed et al. (2002) noted the lack of long-term studies of survivorship and demography in this species. Moreover, their analysis led them to conclude that exploited populations would be slow to recover from harvest of adult turtles due to the delayed maturity and low annual reproductive output of this species. Recently, Folt et al. (2016) reported an annual population growth rate of 1.036 at Spring Creek in Georgia, which suggested the population could double in just 20 years. Folt et al. (2016) concluded that the Spring Creek Alligator Snapping Turtle population may not have experienced extensive commercial harvest. Thus, an assessment of the status of a population with well-documented past commercial harvest was of interest (Johnson 1989, Jensen and Birkhead 2003). In the current study, we re-sampled Alligator Snapping Turtles on a section of Georgia's Flint River to assess the status of the population >20 years after close of commercial harvest with the expectation the population had increased. We also sampled the lower reaches of the Ichawaynochaway Creek, a tributary of the Flint River, much of which was protected from commercial harvest in the past.

Field-site Description

Our study took place on approximately 328 km of the Flint River, GA, from Lake Seminole (near Bainbridge) to north of Highway 19 (near Salem; Fig. 1). The Flint River originates south of Atlanta and merges with the Chattahoochee River at Lake Seminole, an impoundment formed by the Woodruff Dam near the Georgia–Florida border. The main stem of the Flint River is 562 km in length and is one of the least impounded rivers in the US. From its headwaters, the Flint River flows unimpeded for nearly 322 km (Hicks and Opsahl 2002). Impoundments along the Flint River include the Crisp County Power Dam which forms Lake Blackshear, a 32 km reservoir, and the Flint River Dam in Dougherty County, which forms Lake Worth. We also sampled Ichawaynochaway Creek, a 5th-order tributary of the Flint River that originates in Calhoun County and flows into the Flint River in Baker

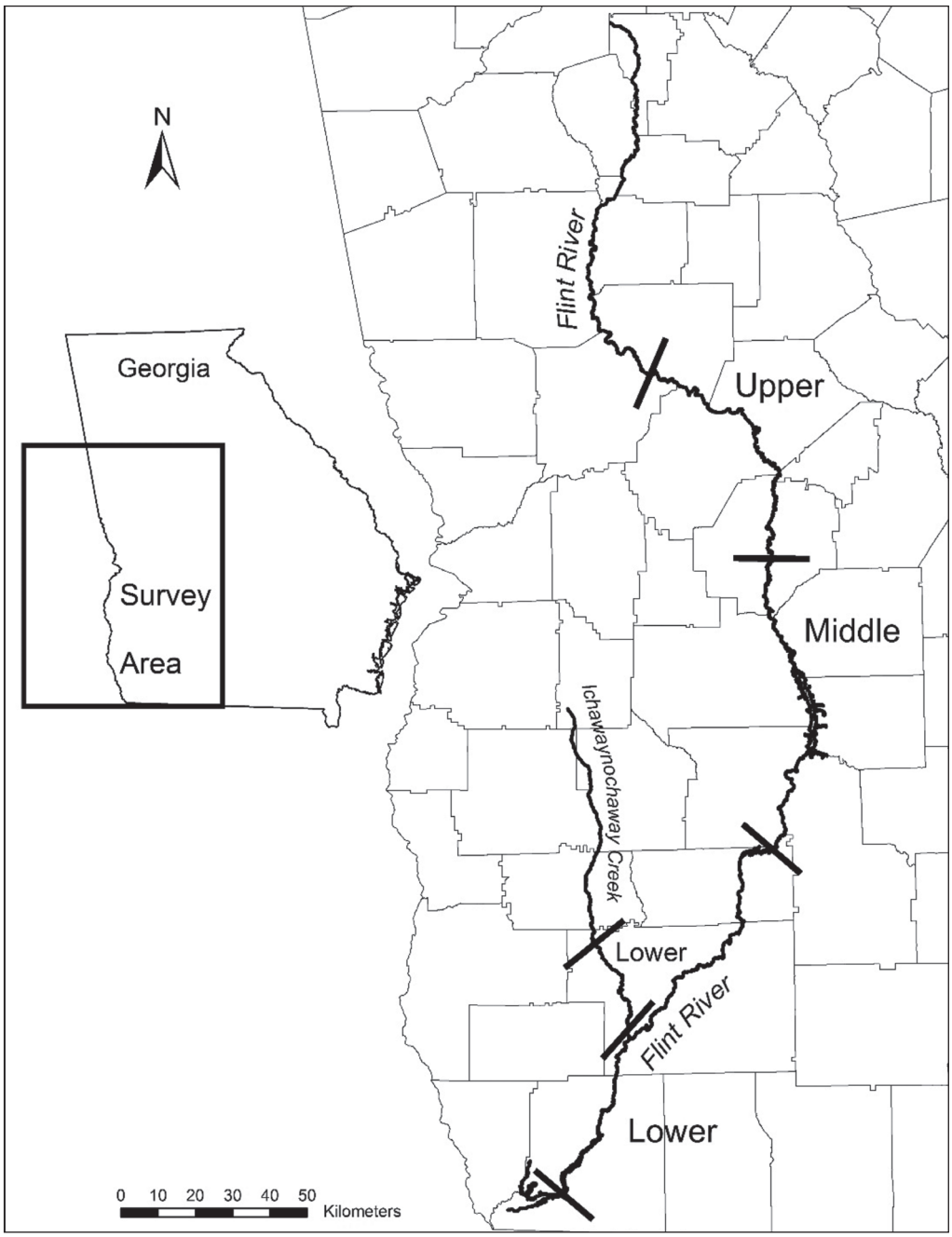

Figure 1. Stream reaches of the Flint River and Ichawaynochaway Creek, GA, trapped for *Macrochelys temminckii* (Alligator Snapping Turtle) in 2014 and 2015. The lower reach of the Flint River between Bainbridge and Albany was 143 km in length, the middle reach of the Flint River between Albany and Montezuma (including Lake Blackshear) was 84 km in length, and the upper reach of the Flint River between Montezuma and Salem was 101 km in length. We sampled 40 km of the lower reach of Ichawaynochaway Creek below Milford, GA.

County, GA. Of the portion of Ichawaynochaway Creek surveyed, the lower 24 km were located within the boundary of Ichauway, the privately owned research site of the Joseph W. Jones Ecological Research Center.

Methods

Study species description

All populations of *Macrochelys* have been considered as one widely distributed species, *Macrochelys temminckii*, until recently. Thomas et al. (2014) described two new species, *Macrochelys apalachicolae* (Choctawhatchee–Ochlockonee drainages) and *Macrochelys suwanniensis* (Suwannee drainage) based on morphological and mitochondrial genetic variation, and retained *M. temminckii* for western populations (Alabama–San Antonio drainages). Our study population on the Flint River in the Apalachicola drainage, would be assigned as *M. apalachicolae* based on the geographic distribution. However, we follow recommendations of Folt and Guyer (2015), who suggested synonymizing *M. apalachicolae* with *M. temminckii* until a proper morphological or molecular diagnosis is provided for those populations. Therefore, we refer to our study population of Alligator Snapping Turtles as *M. temminckii*.

Field sampling

We conducted surveys for Alligator Snapping Turtles from May through September 2014 and May through August 2015. We focused trapping efforts within 3 reaches of the Flint River so that our results could be compared with those of Johnson (1989): lower reach (Bainbridge to Albany, 143 km), middle reach (Albany to Montezuma, 84 km), and upper reach (Montezuma to Hwy 19 in Upson County, 101 km) (Fig. 1). Each of the reaches was divided into continuous ~7.6-km sections for trapping. We also trapped 2 additional sections within Lake Seminole and 3 sections above Highway 19 in Upson County; these data were not included in the comparison with Johnson (1989) as those sections were not trapped in the 1989 study. We also trapped Alligator Snapping Turtles on ~40 km of Ichawaynochaway Creek from Milford, GA, to its confluence with the Flint River (Fig. 1). We used capture success (turtles/trap-night) as a proxy for abundance of Alligator Snapping Turtles in this study and for comparison with results of the 1989 survey (Rodda 2012).

Trapping on the Flint River occurred from 13 May–17 September 2014; 2 sections that could not be trapped in 2014 due to low flows were trapped on 3–4 August 2015. Trapping on Ichawaynochaway Creek took place on 28–29 May and 1–3 June 2015. For most stream sections, we set fifteen 1.2-m-diameter single-throated hoop-nets with 5-cm mesh (Fish Net Company LLC, Jonesville, LA) for one night (15 trap-nights/section); however, there were 2 slightly longer sections on the Flint River, where 20 traps were set (20 trap-nights/section). Traps were baited with cut fish (Jensen 1998) in punctured plastic drink containers, and set directly upstream of Alligator Snapping Turtle microhabitats, such as undercut banks, log jams, limestone outcrops, and deep pools (Harrel et al. 1996, Howey and Dinkelacker 2009, Jensen and Birkhead 2003). We set traps in the afternoon and checked them

the following morning because Alligator Snapping Turtles are primarily nocturnal feeders (Collins 1993).

For all Alligator Snapping Turtles captured, we measured straight-line carapace length (CL) using 50- and 100-cm Haglof calipers (Forestry Suppliers, Inc., Jackson, MS). Turtles were weighed with a 91-kg Viking or Pesola scale (Forestry Suppliers, Inc., Jackson, MS). Sex of turtles was determined by pre-cloacal tail length (Dobie 1971, Lovich 1993); however, we considered all individuals with a CL of <40 cm as immature because it is difficult to differentiate males from females at this size without laproscopy or ultrasound (Folt et al. 2016, Jensen and Birkhead 2003). We checked turtles for previous marks, which included metal tags in the interdigital webbing of the feet and the presence of a passive integrated transponder (PIT) in the base of the tail (Johnson 1989). We marked all Alligator Snapping Turtles uniquely by (1) drilling holes into marginal scutes of the carapace and (2) implanting with PIT tags on the dorsal aspect of the base of the tail (Model HPT12, Biomark, Inc., Boise, ID; Jensen and Birkhead 2003) prior to release.

We used a Fisher's exact test to quantify any potential difference in population structure of Alligator Snapping Turtles in the Flint River and Ichawaynochaway Creek. We tested for differences in size (mean carapace length) of Alligator Snapping Turtles in the Flint River between years (1989 and 2014) and by reach (lower, middle, and upper) using analysis of variance (ANOVA). We used Tukey's multiple comparison of means to identify significant differences among size classes by reach. Analyses were run in Program R (R Core Team 2013); we considered results significant at $P < 0.05$.

Results

We trapped 45 sections of the Flint River and Lake Blackshear; individual sections ranged in length from 4.4–9.2 km and cumulatively totaled 328 km. Trapping was concentrated on the banks of the main channels of Lake Blackshear due to the large overall area of the lake. We also trapped 5 sections of Ichawaynochaway Creek that ranged from 7.7 to 9.0 km in length and totaled 40 km. Trap time averaged 17.1 hours across all sections, and it took approximately 2–4 hours per section to set and check traps.

On the Flint River, we captured 351 individual turtles representing 7 species (Table 1). *Trachemys scripta scripta* (Thunberg in Schoepff) (Yellow-bellied Slider; CPUE = 0.13), *Pseudemys concinna* (Le Conte) (River Cooter; CPUE = 0.13), and *Apalone spinifera aspera* (Agassiz) Gulf Coast Spiny Softshell; CPUE = 0.12) were the most frequently captured species. Six Yellow-bellied Sliders (CPUE = 0.08) and two River Cooters (CPUE = 0.03) were captured on Ichawaynochaway Creek (Table 1).

We captured 56 Alligator Snapping Turtles in 683 trap-nights on the Flint River, yielding an overall CPUE of 0.08 turtles/trap-night (Table 1). No Alligator Snapping Turtles were captured in Lake Blackshear. Of the 56 individuals captured, we observed 14 males, 11 females, and 31 immatures. The proportion of immature turtles was highest in the middle and upper reaches of the river (Fig. 2a). Average

Table 1. Turtle species captured in baited hoop traps on the Flint River and Ichawaynochaway Creek, GA, in 2014 and 2015. Traps were set for 683 nights on the Flint River and 75 trap-nights on Ichawynochaway Creek. CPUE = catch per unit effort (turtles/trap-night).

	Flint River		Ichawaynochaway Creek	
Species	Total	CPUE	Total	CPUE
Apalone ferox (Schneider) (Florida Softshell)	2	0.00	0	0.00
Apalone spinifera aspera (Gulf Coast Spiny Softshell)	79	0.12	0	0.00
Graptemys barbouri Carr and Marchand (Barbour's Map Turtle)	29	0.04	0	0.00
Macrochelys temminckii (Alligator Snapping Turtle)	56	0.08	21	0.28
Pseudemys concinna (River Cooter)	88	0.13	2	0.03
Sternotherus minor (Agassiz) (Loggerhead Musk Turtle)	11	0.02	0	0.00
Trachemys s. scripta (Yellow-bellied Slider)	86	0.13	6	0.08

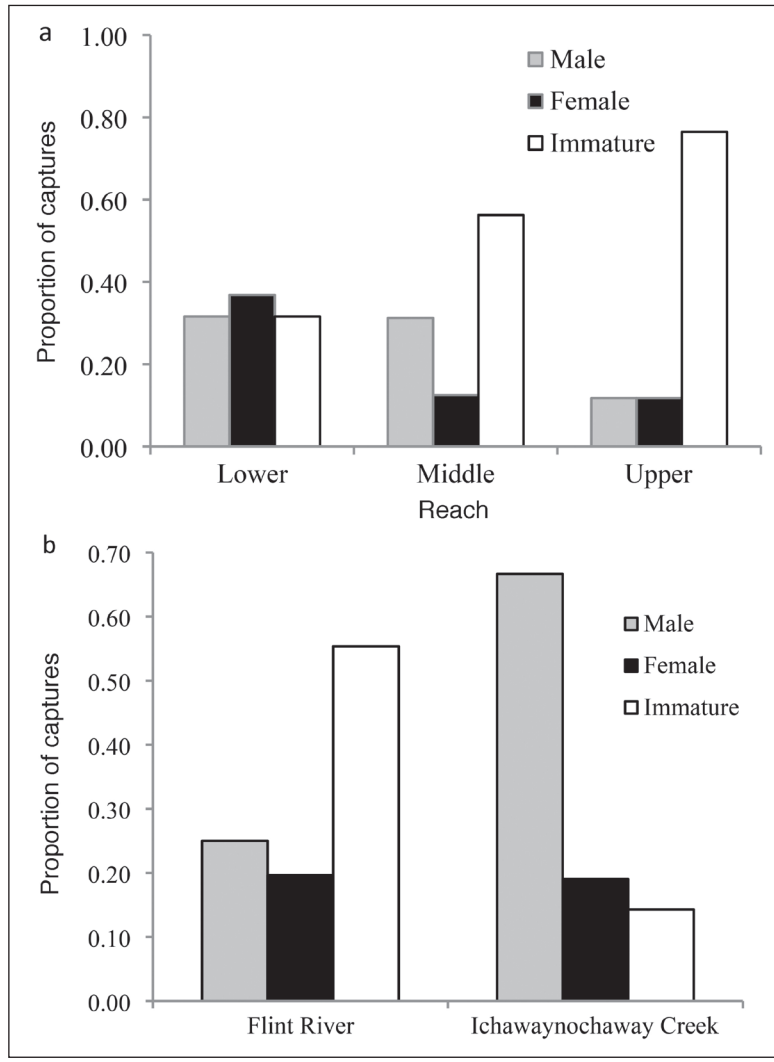

Figure 2. (a) Proportion of male, female, and immature *Macrochelys temminckii* (Alligator Snapping Turtle) captured within 3 reaches of the Flint River (Lower, Middle, and Upper) in 2014–2015. (b) Proportion of male, female, and immature Alligator Snapping Turtles captured on the Flint River and Ichawaynochaway Creek in 2014–2015.

body mass was 15.4 kg (range = 0.5–41 kg), and average carapace length was 38.8 cm (range = 14.8–59.0 cm). None of the 56 turtles captured appeared to have been previously marked.

Twenty-one Alligator Snapping Turtles were captured in 75 trap-nights on Ichawaynochaway Creek, which equated to a CPUE of 0.28 turtles/trap-night (Table 1). Of the individuals captured, 14 were male, 4 were female, and 3 were immature. Average body mass of individuals in Ichawaynochaway Creek was 20.4 kg (range = 2.5–36 kg), and average carapace length was 45.9 cm (range = 24.8–58.9 cm). None of the turtles appeared to have been previously marked. A greater proportion of immature turtles was observed on the Flint River, whereas more mature males were observed on Ichawynochaway Creek (Fishers exact test: $P = 0.001$; Fig. 2b).

Excluding the 4 Alligator Snapping Turtles captured outside of the Johnson (1989) study area, the CPUE observed on the Flint River in our study was 0.09 turtles/trap-night. CPUE was 0.07, 0.08, and 0.11 turtles/trap-night on the lower, middle, and upper reaches, respectively (Table 2). Mean carapace length of Alligator Snapping Turtles did not differ between the 2 studies ($F_{2,107} = 1.81$, $P = 0.17$); however, carapace length differed among reaches ($F_{2,107} = 5.72$, $P = 0.004$). Alligator Snapping Turtles in the lower reach were significantly larger than those in both the middle ($P = 0.010$) and upper reaches ($P = 0.008$) (Fig. 3).

We often found bait bottles destroyed in empty traps (up to 20% of all traps) and suspect either *Alligator mississippiensis* Daudin (American Alligator), *Lontra canadensis* Schreber (River Otter), or Alligator Snapping Turtles may have consumed the bait. American Alligators and River Otters are present in both the Flint River and Ichawaynochaway Creek (Smith et al. 2006) and can readily escape hoop traps or take bait without entering the trap (L.L. Smith, pers. observ.).

Table 2. Results of trapping surveys for *Macrochelys temminckii* (Alligator Snapping Turtle) in 3 sections of the Flint River, Georgia from Johnson (1989) and this study (2014–2015). Four Alligator Snapping Turtles captured near Lake Seminole and north of Salem, outside the area sampled by Johnson (1989) were not included. # = number of turtles captured; CPUE = catch-per-unit-effort (turtles/trap-night).

Section		Johnson (1989)	This study (2014–2015)
Bainbridge to Albany (Lower reach)	#	8	19
	Trap-nights	325	255
	CPUE	0.02	0.07
Albany to Montezuma (Middle reach)	#	40	16
	Trap-nights	326	195
	CPUE	0.12	0.08
Montezuma to Salem (Upper reach)	#	14	17
	Trap-nights	132	148
	CPUE	0.11	0.11
All reaches	#	62	52
	Trap-nights	783	598
	CPUE	0.08	0.09

Discussion

The capture rate of Alligator Snapping Turtles on the Flint River in our study was quite low (0.09 turtles/trap-night) and nearly identical to that reported in 1989 (0.08 turtles/ trap-night; Johnson 1989). Capture success in our study compared to the 1989 survey was similar in the upper reach, decreased slightly in the middle reach, and increased in the lower reach. Mean size of Alligator Snapping Turtles on the Flint River did not differ between the 2 surveys. However, turtles we caught in the lower reach were significantly larger than those in the middle and upper reaches. We caught nearly twice as many immature Alligator Snapping Turtles as adult males and females, and the highest proportion of immature turtles was captured in the upper reach between Montezuma and Salem.

There were minor differences in sampling methodology between our study and Johnson (1989). For example, Johnson (1989) sunk the traps rather than leaving them partly exposed to air, which may have increased the trapping success but also increased risk of drowning turtles (7 of 62 turtles captured, 11%, were dead in traps in that study). We also suspect that some Alligator Snapping Turtles may have escaped our traps, based on damage to bait bottles, although some or all of the damage may have been caused by American Alligators or River Otters. However, these factors are unlikely to have obscured general patterns observed between the 2 surveys. Capture rates from both surveys were much lower than the anecdotal report of 1.00 turtles/trap-night from the 1970s (Johnson 1989). Our capture rate on the Flint River was also much lower than that of Ichawaynochaway Creek in this study (0.28 turtles/trap-night), and that of another Georgia stream, Spring Creek, where Jensen and Birkhead (2003) captured 0.45 turtles/trap-night using similar trapping methods to our study. Jensen and Birkhead (2003) and Folt et al. (2016) suggested that the population in Spring Creek was minimally impacted by harvest and may represent a reference population. Ichawaynochaway Creek also was protected from

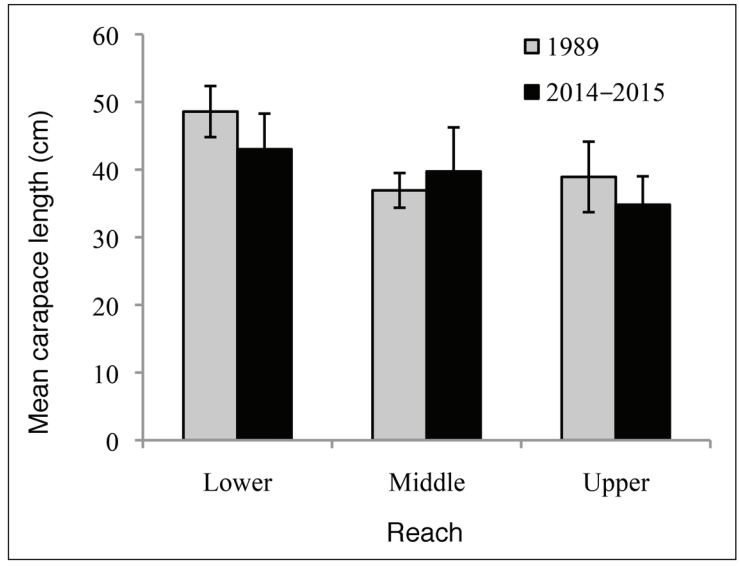

Figure 3. Mean carapace length (with 95% CI) of *Macrochelys temminckii* (Alligator Snapping Turtle) captured in 3 reaches of the Flint River (Lower, Middle, and Upper) in a survey conducted by Johnson (1989) and in the current study (2014–2015).

commercial turtle harvest in the 1970s and 1980s within the boundaries of Ichauway Reserve because the property owners limited public access to the creek (J. Atkinson, Joseph W. Jones Ecological Research Center, Newton, GA, pers. comm.). However, prior to state listing, occasional harvest of individual turtles caught on limb lines set for catfish may have occurred. Additional work on this population may be necessary to determine whether it is stable, increasing, or decreasing.

We did not capture any Alligator Snapping Turtles that we could verify were marked in the 1989 survey. The metal tags used in the 1989 study may have fallen out over the past 25 years. However, we also did not detect PIT tags in any turtles captured in our study, which suggests that either these tags, which were implanted at the base of the tail, may also have been lost or that our effort yielded only captures of unmarked animals.

Overall, our data suggest that despite 22 years of protection from commercial harvest, the Alligator Snapping Turtle population in the Flint River has not responded by increasing in abundance. The lack of a detectable response may be a consequence of delayed maturity in this species (e.g., Folt et al. [2016] reported a mean generation time of 31.2 years [range = 28.6–34.0 years, 95% CI]) and low reproductive output in this species (Dobie 1971, Ewert et al. 2006, Reed et al. 2002). Although we did not observe mortality of Alligator Snapping Turtles due to illegal harvest or drowning on abandoned limb lines during our study, these activities could contribute to slow recovery of the population. We recommend additional monitoring of the status of Alligator Snapping Turtles on the Flint River and proactive outreach to sportsmen regarding maintenance and removal of sport trotlines, set hooks, and jugs.

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