A Trapping Survey Targeting Head-Started Alligator Snapping Turtles in Southwest Louisiana

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Abstract

The alligator snapping turtle *Macrochelys temminckii* is the largest freshwater turtle in North America and humans seek it as a food source, primarily in Louisiana. Scientists point to decades of intensive commercial harvest of alligator snapping turtles as a cause of population declines. The Louisiana Department of Wildlife and Fisheries initiated a head-start program for alligator snapping turtles and released 53 head-started juveniles at seven sites along an approximately 5.7-km stretch of Bundick Creek in southwest Louisiana between November 2015 and October 2016. Before release, department personnel measured, weighed, and marked all alligator snapping turtles with both an internal passive integrated transponder tag and a numbered external tag. In 2018, the U.S. Geological Survey initiated a turtle trapping survey at those seven release sites targeting the head-started alligator snapping turtles. In 1 wk of trapping effort at each site, we recorded 69 turtle captures comprising seven species, including 15 alligator snapping turtles (representing 12 individuals). Of those 12 individuals, 8 were head-started juveniles and 4 were native to the creek. A landowner captured an additional head-started juvenile alligator snapping turtle during our trapping and we took measurements before its release. A minimum of 17% of head-started alligator snapping turtles survived since release, and we trapped most captured head-started individuals near their release site; the captured individuals exhibited growth consistent with other studies, indicating acclimatization to their new environment. Three head-started alligator snapping turtles had their external tags entangled in the net mesh, and two of these turtles drowned. An additional two head-started individuals lost their external tags in the natural environment prior to their capture in this study. The Louisiana Department of Wildlife and Fisheries discontinued the use of external tags based on our findings, as these tags were detrimental to the health of head-started turtles.

Keywords: alligator snapping turtle; growth; Louisiana; *Macrochelys temminckii*; methodology

Received: February 10, 2020; Accepted: August 6, 2020; Published Online Early: August 2020; Published: December 2020

Citation: Glorioso BM, Muse LJ, Hillard CJ, Maldonado BR, Streeter J, Battaglia CD, Waddle JH. 2020. A trapping survey targeting head-started alligator snapping turtles in southwest Louisiana. *Journal of Fish and Wildlife Management* 11(2):572–582; e1944-687X. https://doi.org/10.3996/JFWM-20-009

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Introduction

The alligator snapping turtle *Macrochelys temminckii* is the largest freshwater turtle in North America, with males known to exceed 90 kg (Pritchard 1989). Due to its secretive, aquatic existence, scientists knew little of its ecology until the 1990s, with most prior information coming from examinations and dissections of harvested animals (Ewert 1976; Reed et al. 2002; but see Dobie 1971). Alligator snapping turtles are a highly aquatic and long-lived species, with reports of individuals in excess of 80 y of age in captivity, although scientists know less of wild longevity (Ewert et al. 2006). Alligator snapping turtles have delayed maturity, with reports of 11–13 y to maturity from a sample of 231 Louisiana individuals (Dobie 1971), and 11–21 y to maturity from a sample of 93 individuals taken primarily in Louisiana (Tucker and Sloan 1997). Females lay only one clutch per year with a relatively low output of eggs compared to the smaller snapping turtle *Chelydra serpentina*, and clutch size is positively correlated with female size (Dobie 1971; Tucker and Sloan 1997). Ewert and Jackson (1994) recorded a mean clutch size of 35.1 eggs, with a maximum of 52, from 160 Florida clutches, but mean clutch sizes reported from Louisiana tend to be smaller, possibly as a result of differential harvest pressures (Dobie 1971; Tucker and Sloan 1997).

Historically, the alligator snapping turtle occurred in 14 states in the United States, with its core range located along the Lower Mississippi River (Pritchard 1989). Scientists have now noted population declines throughout the range, and have identified overharvesting for domestic and international food markets as a primary cause in many areas (Dobie 1971; Pritchard 1989; Sloan and Lovich 1995; Reed et al. 2002). Continued harvest of adults, particularly females, is detrimental to long-term population persistence of any turtle species (Congdon et al. 1993, 1994). In 1984, a petition to list the alligator snapping turtle as threatened or endangered under the United States Endangered Species Act (ESA 1973, as amended) was declined by the U.S. Fish and Wildlife Service (USFWS) due to insufficient data (USFWS 1984). In 1991, the USFWS formally listed the alligator snapping turtle as an Endangered Species Act candidate, meaning the USFWS had sufficient information to propose them as threatened or endangered, but higher priority listing activities precluded the development of a proposed listing regulation (USFWS 1991). In response to a 2012 petition to list the alligator snapping turtle under the Endangered Species Act from the Center for Biological Diversity, the USFWS conducted a review, culminating in a 90-d finding that substantial information exists that may warrant listing of the alligator snapping turtle as threatened or endangered under the ESA (Adkins Giese et al. 2012; USFWS 2015). At the conclusion of the status review that follows the 90-d finding, the USFWS will issue a 12-mo finding, with a decision to list as threatened or endangered, or not to list, expected in 2020.

After placing commercial size and recreational take limits on alligator snapping turtles in 1993, Louisiana became the last state to ban the commercial harvest of alligator snapping turtles in 2004 (Pritchard 2006). However, those holding a valid basic resident or nonresident Louisiana fishing license may still take any size alligator snapping turtle recreationally, with a limit of one per person, per day, per vehicle or vessel (LDWF 2020). Despite the legal recreational harvest, in 2012 the Louisiana Department of Wildlife and Fisheries (LDWF) commenced a head-start program for alligator snapping turtles. Head-starting is a conservation technique involving raising young animals until they attain a large enough size to be released into the wild, with the goal of increasing survival and recruitment rates compared to animals that are not head-started. Head-starting as a conservation tool has been around for decades in sea turtle species, and the earliest known alligator snapping turtle captive breeding program began in 1999 at Tishomingo National Fish Hatchery in Oklahoma (Pritchard 1979; Riedle et al. 2008). Burke (2015) reviewed the history, practice and criticisms of head-starting in turtles. The purpose of the LDWF program was to determine the viability of a Louisiana-based head-start program to supplement wild alligator snapping turtle populations.

Boundy and Kennedy (2006) trapped 33 sites in southeast Louisiana for alligator snapping turtles, noting that the lack of young turtles captured possibly indicated low recruitment. Holcomb and Carr (2011) documented only 38 emerged hatchlings from 16 monitored natural alligator snapping turtle nests from 2008–2009 in northeast Louisiana. In the same study area, all 90 monitored artificial alligator snapping turtle nests (which used medium-sized chicken eggs as a substitute) were

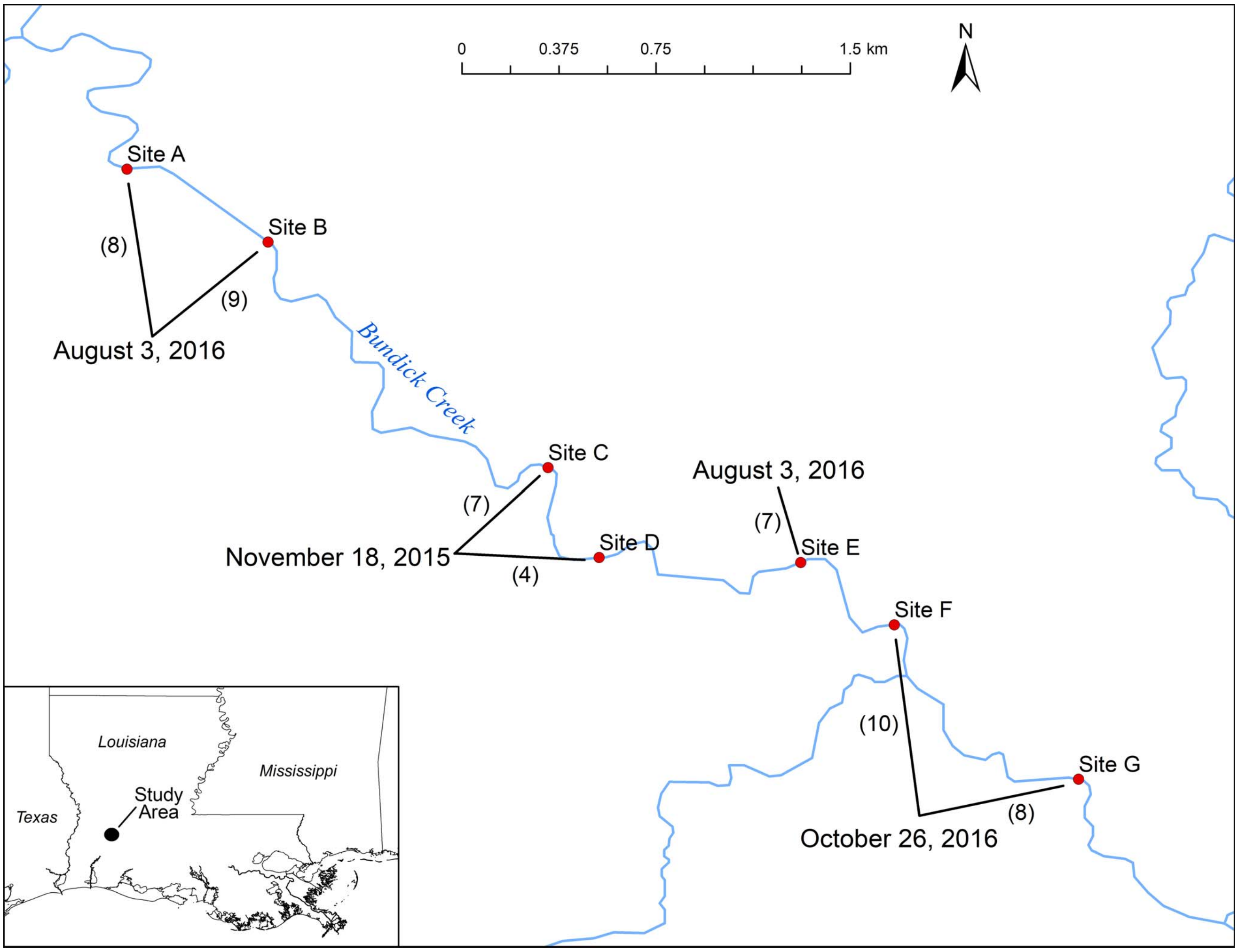

Figure 1. Study sites along Bundick Creek in southwest Louisiana (Beauregard Parish) where the Louisiana Department of Wildlife and Fisheries released head-started alligator snapping turtles *Macrochelys temminckii* from 2015 to 2016. The figure shows release dates and locations along with the number of turtles released at each site in parentheses.

depredated, primarily by raccoons *Procyon lotor* and nine-banded armadillos *Dasypus novemcinctus*, with 85.6% of them depredated in the first 24 h (Holcomb and Carr 2013). Annual survivorship increases with age, a correlate of size in turtles, likely due to reduced predation risks (Frazer et al. 1990; Iverson 1991; Haskell et al. 1996; Heppell et al. 1996; Dreslik et al. 2017). Scientists presume that by head-starting alligator snapping turtles in captivity, where supplemental food and heating accelerate growth, survival rates upon release are greater than the combined survival of wild nests and natural-born hatchlings.

The U.S. Geological Survey was aware of the LDWF head-start program but was not involved with its conception, planning, or execution, first learning of the specific release sites in spring 2018 after inquiry. After discussion with LDWF staff, our objective was to capture head-started alligator snapping turtles that LDWF released years prior into Bundick Creek in southwest Louisiana. We collected size and locality information on captured head-started alligator snapping turtles to compare with initial release data. Ancillary to our main objectives, we examined differences in catch per unit effort (CPUE) with respect to trap days, hoop net diameter, and bait type. LDWF managers can use this information to gauge the efficacy of this release and inform future releases and monitoring.

Methods

LDWF personnel released 53 head-started juvenile alligator snapping turtles at seven sites along an approximately 5.7-km section of Bundick Creek in Beauregard Parish between 18 November 2015 and 26 October 2016 (Figure 1). The LDWF recognizes Bundick Creek as a Natural and Scenic River; it is a tributary of another Natural and Scenic River, Whiskey Chitto Creek, which empties into the Calcasieu River. The LDWF chose this site because of its habitat suitability for alligator snapping turtles (sandy-bottomed, flowing creek of varying depths with abundant submerged and downed logs and trees), its remoteness (no motorized boat access), and the cooperation of landowners. This cohort

Figure 2. One of eight head-started alligator snapping turtles *Macrochelys temminckii* captured in 2018 in hoop nets along Bundick Creek in southwest Louisiana during this study. Note its external tag located posteriorly.

was hatched in 2012 at a Louisiana commercial turtle farm and transferred to a LDWF hatchery in Monroe, Louisiana, in early 2013. LDWF personnel assumed all released head-started alligator snapping turtles to be female due to egg incubation temperatures at the turtle farm. A veterinarian nondestructively examined a subset of 10 young alligator snapping turtles using laparoscopy prior to initial release and all were female, supporting the assumption of an all-female cohort. LDWF personnel measured all turtles for midline carapace length and carapace maximum width to the nearest millimeter and weighed them to the nearest gram before release. In addition, they marked turtles with both an internal passive integrated transponder (PIT) tag (Biomark HPT12) and an external metal tag etched with a unique identification (ID) number along with an LDWF phone number to call if a turtle were captured or found. This study is the first to attempt to capture these head-started alligator snapping turtles released in Bundick Creek.

We trapped four consecutive nights at each of the seven release sites along Bundick Creek during 4 wk between late June and early October 2018. We trapped two release sites concurrently each of the first 3 wk and trapped the remaining release site the last week of the study. We set nets each week on Monday morning and checked them once daily for four consecutive days. We removed the nets from the creek after checking on Friday. We used 19 hoop nets consisting of 10 1.22-m-diameter hoop nets with 4.76-cm mesh (large nets), 6 0.91-m-diameter hoop nets with 2.54-cm mesh (midsize nets), and 3 0.76-m-diameter hoop nets with 2.54-cm mesh (small nets). We used 9 or 10 nets at each site, consisting of 5 large nets, 3 midsize nets, and either 1 or 2 small nets. We set the nets in the creek near areas where alligator snapping turtles are known to inhabit, such as areas of downed logs and trees and deep holes. We placed traps upstream of the area we were trying to trap with the funnel of the trap facing downstream. Therefore, we hoped, the turtle would pick up the scent and head upstream into our traps.

We baited all hoop nets on Monday morning with fish, either cut bait (composed of carp *Cyprinus carpio* and *Ctenopharyngodon idella* and buffalo *Ictiobus* sp.) or Gulf menhaden *Brevoortia patronus*. We placed the fish into 7.62-cm-diameter polyvinyl chloride cylinders that were suspended from the rear-most hoop. Cylinders were 20.32 cm in length for 0.91- and 0.76-m-diameter nets, and 30.48 cm in length for 1.22-m-diameter nets. We drilled many 1.91-cm holes in each cylinder to allow the scent of the bait to disperse and capped all cylinders at both ends with 7.62-cm polyvinyl chloride snap-in drains. We baited a nearly equal number of nets with either cut bait or Gulf menhaden, alternating bait types in each trap along the creek. We replaced bait in each net on Wednesday with the opposite bait type.

We measured carapace length, carapace width, and plastron length to the nearest millimeter, and mass to the nearest 25 g for each captured alligator snapping turtle. We visually checked each turtle for an external tag on the back of the carapace and then scanned it for a PIT tag. If we detected neither an external tag nor a PIT tag, we considered the turtle to be native to the creek (not a head-started turtle). We injected alligator snapping turtles native to the creek with a PIT tag (Biomark HDX12) under the skin near the bridge and notched them with a small hand saw on the marginal scutes of the carapace (Cagle 1939), giving each turtle a unique three-letter code (Dorcas 2005). After processing, we released all captured turtles near the net of capture. We performed a likelihood ratio test to estimate the χ^2 goodness of fit of the observed distribution of some methodological aspects of this study, including captures per day, captures by hoop net diameter, and bait selection. We used Welch's *t*-test for two samples assuming unequal variances to compare growth in Harrel et al. (1997) to this study. We set significance at $\alpha = 0.05$.

Results

We caught 69 turtles comprising 7 species during 16 d of trapping (Data S1, *Supplemental Material*; Table 1). We had 15 alligator snapping turtle captures representing 12 individuals. Of the 12 individual alligator snapping turtles, 8 were head-started individuals and 4 were native to the creek (Figure 2). A landowner caught one additional head-started alligator snapping turtle by rod and reel and held it for us to measure before release. Of the four alligator snapping turtles native to the creek, three were juveniles of unknown sex (carapace length range 22.3–27.0 cm, mass 2.30–4.35 kg), and one was an adult male (carapace length 50.9 cm, 30.5 kg).

We observed considerable growth in carapace length and width, as well as mass, in seven of the nine captures (Table 2). Of those seven, growth varied from 1.2 to 2.7 cm/y in carapace length and from 1.4 to 2.5 cm/y in carapace width (Table 2). Mass gain of those seven varied from 0.4 to 1.2 kg/y. One individual (ID 102) grew only 0.3 cm/y in carapace length and 0.5 cm/y in carapace

Table 1. Total turtles captured in all trapping periods at Bundick Creek in southwest Louisiana (Beauregard Parish) in 2018. We assumed all head-started alligator snapping turtles *Macrochelys temminckii* to be female but did not include them in the table below due to uncertainty, nor did we include three juvenile alligator snapping turtles captured that were native to the creek. Therefore, counts by sex below are only for individuals exhibiting secondary sexual characteristics.

Species	Total captures	Individuals captured	Sex (M : F)	Total recaptures
Alligator snapping turtle *Macrochelys temminckii*	15	12	1:0	3
Razor-backed musk turtle *Sternotherus carinatus*	24	21	10:11	3
Spiny softshell *Apalone spinifera*	6	6	5:1	0
Red-eared slider *Trachemys scripta elegans*	17	14	8:6	3
Mississippi map turtle *Grapetmys pseudogeographica kohnii*	2	2	0:1	0
Sabine map turtle *Graptemys sabinensis*	4	4	2:2	0
Eastern musk turtle *Sternotherus odoratus*	1	1	1:0	0

width, whereas another individual (ID 89) grew only 0.7 cm/y both in carapace length and width. ID 89 gained only 0.05 kg/y in mass, whereas ID 102 lost mass since its release nearly 2 y prior (Table 2). We found no significant difference in growth rates in carapace length ($t = 0.589$, $df = 16$, $P = 0.718$), carapace width ($t = 1.503$, $df = 16$, $P = 0.924$), or mass ($t = 1.033$, $df = 16$, $P = 0.841$) of our head-started alligator snapping turtles compared to Harrel et al. (1997).

The two head-started alligator snapping turtles with the least amount of growth by carapace length, width, and mass were also the individuals that we captured farthest from their initial release site, with ID 102 captured over 4 km in creek length from its initial release site. We captured all other head-started alligator snapping turtles a mean of 391 m (range = 36–729 m) from their initial release site. We captured one individual (ID 28) on three consecutive days, initially capturing it 299 m downstream from its original release site. The next day we captured it 65 m upstream from its previous capture the day prior, and then captured it once more on the third consecutive day 374 m downstream from the previous day.

More than half of all alligator snapping turtle captures occurred on the first day of checking the nets, with each successive day of net checks capturing half the alligator snapping turtles as the previous day, despite replacing bait midweek (Table 3). Captures per trap check day was not significantly different from the null for the 15 alligator snapping turtle captures ($\chi^2_3 = 7.481$, $P = 0.058$), but was significantly different for the 69 total turtle captures ($\chi^2_3 = 21.756$, $P < 0.001$). Though we captured the two most commonly trapped species in traps in similar proportions with regard to bait type (both $P \geq 0.8$), we captured alligator snapping turtles more often with cut bait than with Gulf menhaden (11 and 4 captures, respectively), but this difference was not statistically significant ($\chi^2_1 = 3.397$, $P = 0.065$). The CPUE, or turtles per trap night, was significantly different for all captures based on hoop net diameter, with the largest diameter capturing more than expected and the smallest diameter fewer than expected ($\chi^2_2 = 10.673$, $P \leq 0.005$; Table 4). However, for alligator snapping turtle captures only, there was no significant difference in CPUE by hoop net diameter ($\chi^2_2 = 1.000$, $P = 0.606$; Table 4). Total CPUE among all net sizes for alligator snapping turtles was 0.056.

The two alligator snapping turtles (ID 89 and ID 102) with the least amount of observed growth drowned due to entanglement of the external tag in the mesh. One deceased alligator snapping turtle (ID 89) was entangled at the bottom of the hoop net by the actual circle tag that had the turtle ID and phone number etched on it. The other deceased alligator snapping turtle (ID 102) was caught in the mesh on the outside of the hoop net by the loop of the rod attachment (Figures 3A and 3B). We captured one alligator snapping turtle (ID 21) with a different type of external tag attachment method. It used stainless-steel wire to attach the tag to the turtle's carapace. This was the only head-started alligator

Table 2. Growth data for nine captured head-started alligator snapping turtles *Macrochelys temminckii* at Bundick Creek in southwest Louisiana (Beauregard Parish) in 2018. See Figure 1 for site locations.

	Release		Recapture			Carapace length			Carapace width			Mass		
ID	Date	Site	Date	Site	Growth years	At release (cm)	At recapture (cm)	Growth rate (cm/y)	At release (cm)	At recapture (cm)	Growth rate (cm/y)	At release (kg)	At recapture (kg)	Growth rate (kg/y)
21	18 November 2015	D	14 August 2018	D	2.74	25.6	30.8	1.9	22.6	27.6	1.8	4.921	7.500	0.9
28	18 November 2015	C	14 August 2018	C	2.74	24.6	27.8	1.2	21.8	26.1	1.6	3.964	6.100	0.8
53	3 August 2016	E	26 June 2018	F	1.90	22.5	26.1	1.9	21.0	24.4	1.8	3.400	4.500	0.6
59	26 October 2016	F	29 June 2018	E	1.67	21.5	26.0	2.7	19.0	23.1	2.4	2.854	4.900	1.2
73	26 October 2016	G	27 June 2018	G	1.67	22.2	26.0	2.3	20.2	24.3	2.5	2.912	4.550	1.0
82	3 August 2016	E	26 June 2018	E	1.90	18.7	21.4	1.4	16.5	19.1	1.4	1.864	2.700	0.4
89[a]	3 August 2016	A	28 June 2018	F	1.90	19.9	21.2	0.7	17.6	18.9	0.7	2.200	2.300	0.1
102[a]	3 August 2016	F	14 August 2018	D	2.03	17.8	18.4	0.3	15.5	16.5	0.5	1.486	1.375	-0.1
114	26 October 2016	F	26 June 2018	E	1.67	21.2	23.8	1.6	18.7	21.9	1.9	2.242	3.150	0.5

[a] Individuals drowned by getting external tag caught in hoop net.

Table 3. Total captures by day of sampling period for all 4 wk of trapping combined at Bundick Creek in southwest Louisiana (Beauregard Parish) in 2018. We replaced bait with opposite bait type after day 2 net checks.

Species	Day 1	Day 2	Day 3	Day 4	Total captures
Alligator snapping turtle *Macrochelys temminckii*	8	4	2	1	15
Razor-backed musk turtle *Sternotherus carinatus*	13	4	6	1	24
Spiny softshell *Apalone spinifera*	1	1	2	2	6
Red-eared slider *Trachemys scripta elegans*	7	4	4	2	17
Mississippi map turtle *Grapetmys pseudogeographica kohnii*	2	0	0	0	2
Sabine map turtle *Graptemys sabinensis*	1	2	1	0	4
Eastern musk turtle *Sternotherus odoratus*	1	0	0	0	1
Total	33	15	15	6	69

snapping turtle captured after the previous deaths, and under advisement of the LDWF, we removed this external tag before release (Figure 3C).

Turtle ID 59 was also entangled in the mesh by the loop of the rod attachment. We cut it free of the net, and it seemed to be able to surface for air and behaved normally. Including the two drowned turtles, three of the six individuals with external LDWF tags present were entangled in the nets. Two head-started individuals lost their external tags prior to their capture in this study, as evidenced by the hole in the marginal scute where the tag would have been, and its still-retained internal PIT tag.

Discussion

Dreslik et al. (2017) reported that 25% of radio-tracked juvenile alligator snapping turtles released over 3 y in Louisiana died within the first year. They reported a slightly lower percentage for Oklahoma (21.7%) and a slightly higher percentage for Illinois (28.8%). Apparent survival rate in juveniles for a declining Oklahoma population was 46% (East et al. 2013). Howey and Dinkelacker (2013) reported juvenile annual apparent survivorship in an Arkansas population recovering from historic commercial harvest of 80%, similar to the 86% Folt et al. (2016) reported in a Georgia population. Anthony et al. (2015) showed apparent survivorship that differed by age at release, with survivorship increasing from 59, to 70, to 100% for 3, 4, and 5-y-old releases, respectively. However, capture rates were low at 4, 11, and 19% for 3, 4, and 5-y-old releases, respectively. In this study, we captured about 15% of the head-started individuals released. When including the incidental capture of ID 73, that percentage is 17%. This likely represents an underestimate of true survival as some individuals may have permanently emigrated from the release area and were not available for capture, and others may be in the release area but went uncaptured (imperfect detection).

In its simplest form, CPUE is where catch is directly proportional to both effort and population size (Schaefer 1954). Two general assumptions of using CPUE are that the population is closed to unknown changes during the study and that all individuals are equally catchable (Lancia et al. 1996). It is likely that we have violated the equally catchable assumption if we are less likely to capture turtles on subsequent days of trapping (Table 3). We also acknowledge that our CPUE would have been higher had we trapped fewer days, given trap success decline over the course of each week of trapping, despite bait replacement. However, we believe there is still value in reporting CPUE as a comparison to other studies, given these caveats.

Our overall CPUE of 0.056 alligator snapping turtles per trap night is within the range of several studies reporting an overall CPUE of alligator snapping turtles of less than 0.1 turtle per trap night (Table 5). Scientists often find these low capture rates in areas at the periphery of the species range, or in areas where they know or suspect historical harvest to have occurred.

Table 4. Catch per unit effort (CPUE) by hoop net size (diameter) for all trapping periods combined at Bundick Creek in southwest Louisiana (Beauregard Parish) in 2018.

Species	Total captures	CPUE, 1.22-m hoop nets[a] (no. of captures)	CPUE, 0.91-m hoop nets[b] (no. of captures)	CPUE, 0.76-m hoop nets[c] (no. of captures)
Alligator snapping turtle *Macrochelys temminckii*	15	0.063 (9)	0.060 (5)	0.025 (1)[d]
Razor-backed musk turtle *Sternotherus carinatus*	24	0.132 (19)	0.060 (5)	0
Spiny softshell *Apalone spinifera*	6	0.021 (3)	0.036 (3)	0
Red-eared slider *Trachemys scripta elegans*	17	0.083 (12)	0.048 (4)	0.025 (1)
Mississippi map turtle *Grapetmys pseudogeographica kohnii*	2	0.014 (2)	0	0
Sabine map turtle *Graptemys sabinensis*	4	0.021 (3)	0.012 (1)	0
Eastern musk turtle *Sternotherus odoratus*	1	0	0	0.025 (1)
Total	69	0.333 (48)	0.214 (18)	0.075 (3)

[a] 144 trap nights.
[b] 84 trap nights.
[c] 40 trap nights.
[d] Refers to alligator snapping turtle tangled on outside of net.

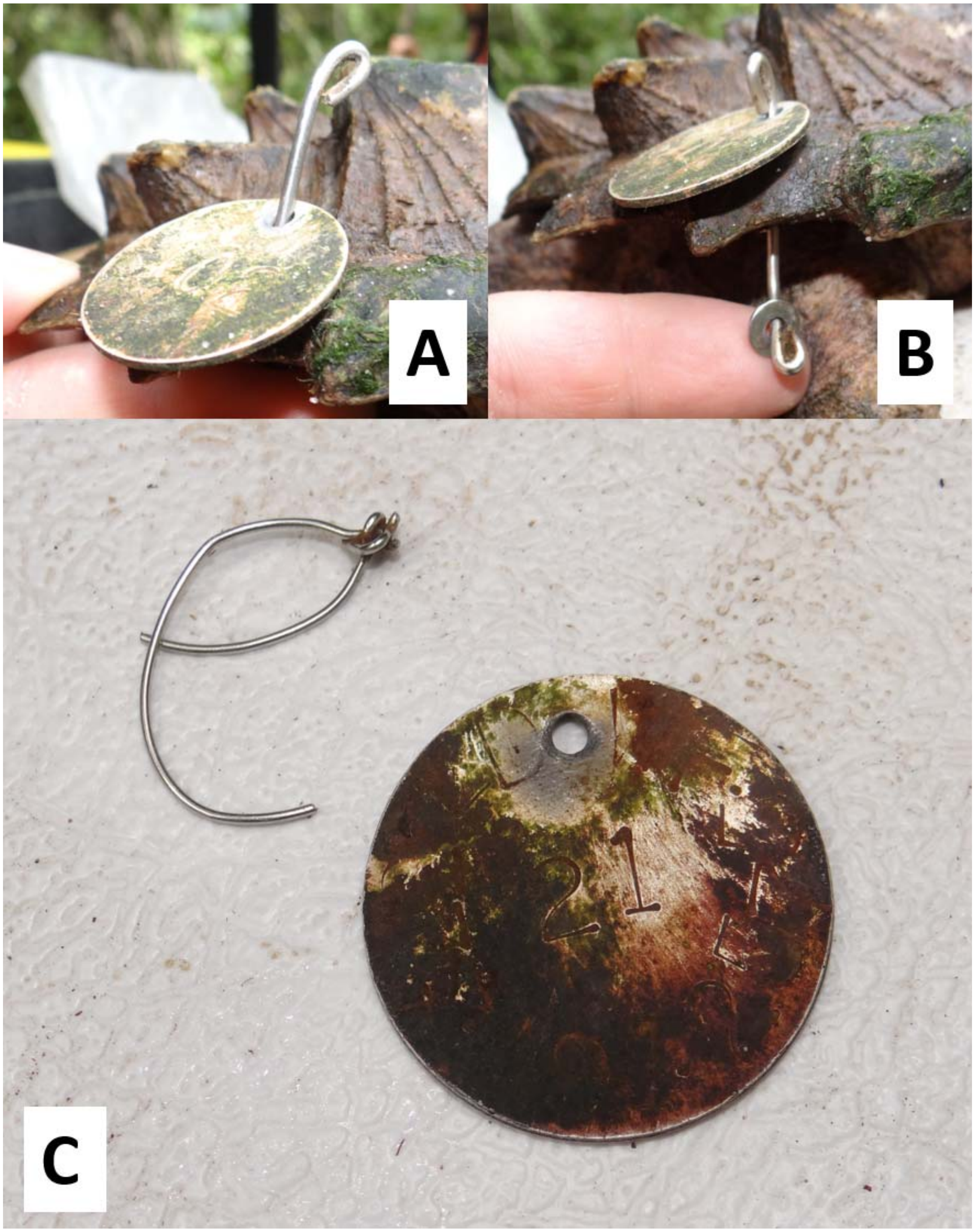

Figure 3. (**A** and **B**) Photographs of the external tag of alligator snapping turtle *Macrochelys temminckii* ID 102 that drowned while caught on the outside of the hoop net by the upper loop of the rod attachment. (**C**) The external tag of ID 21 that we removed. This individual was not entangled in the net, but under advisement from the Louisiana Department of Wildlife and Fisheries, we cut the tag off. All other head-started individuals captured at Bundick Creek in southwest Louisiana (Beuaregard Parish) in 2018 with present external tags had the style of A and B.

Though overall CPUE among many sites in some studies is low, individual sites can have a much higher CPUE, perhaps indicating less historical pressure on these populations. For instance, Folt and Godwin (2013) reported a CPUE of 0.478 turtles per trap night from the Fowl River in Alabama, and Riedle et al. (2005) reported a CPUE of 0.410, 0.444, and 0.620 in Oklahoma at Little Vian, Dutchess, and Mill creeks, respectively.

Harrel et al. (1997) reported growth data after 1 y of radio-tracking 12 wild-caught juvenile alligator snapping

Table 5. Comparison of catch per unit effort (CPUE) of alligator snapping turtles *Macrochelys temminckii* among previous studies to this study. Effort is given in trap nights, defined as one net set for one night.

State	Total effort	Total captures	Overall CPUE	Study
Oklahoma	1,085	63	0.0580	Riedle et al. 2005
Louisiana	3,504	200	0.0571	Boundy and Kennedy 2006
Alabama	1,332	93	0.0698	Folt and Godwin 2013
Georgia	683	56	0.0820	King et al. 2016
Louisiana	731	16	0.0219	Huntzinger et al. 2019
Louisiana	268	15	0.0560	This study

turtles in north Louisiana, 9 of which a veterinarian determined by laparoscopy to be female. As we presumed all nine of our head-started alligator snapping turtles to be females, we made a comparison with the caveat that only one of our releases was larger than the mean carapace length reported in Harrel et al. (1997). We found no significant difference in growth in carapace length, width, or mass of wild juveniles in Harrel et al. (1997) compared to our head-started alligator snapping turtles (Figure 4). Moore et al. (2013) found that hatchery-raised released juveniles near the border of Texas and Oklahoma gained more mass than those retained at the Tishomingo National Fish Hatchery. Likewise, Anthony et al. (2015) found that annual growth rates were higher in released juveniles than in those that remained in captivity for the same period in 3 of the 4 y they monitored. Moore et al. (2013) estimated that the growth rates of released head-started alligator snapping turtles were between 1.8 and 3.2 cm/y. These are generally higher growth rates than we found in this study; however, the initial release size in Moore et al. (2013) was generally smaller, which may confound that comparison. In fact, though there was overlap in initial carapace lengths at release, the largest turtle (by mass) in Moore et al. (2013) was smaller than the mass at release of any captured alligator snapping turtle in this study. In addition, due to the elapsed time of nearly 2–3 y between release and capture of head-started alligator snapping turtles in this study, it is unknown if the observed growth was continual or exhibited some other pattern during that period, also possibly confounding our comparisons.

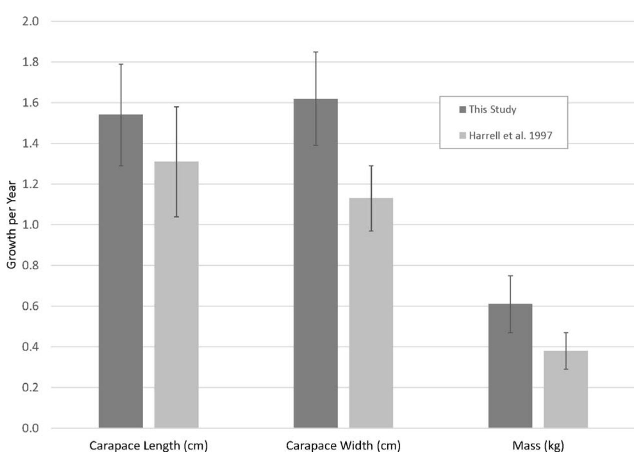

Figure 4. A comparison of mean growth ± SE of carapace length, carapace width, and mass of juvenile alligator snapping turtles *Macrochelys temminckii* from this study at Bundick Creek in southwest Louisiana (Beauregard Parish) in 2018 to a study by Harrel et al. (1997), which radio-tracked wild-caught individuals in northeast Louisiana. We presumed all nine captured head-started juveniles in this study to be female and compared them with the nine wild-caught juvenile females in Harrel et al. (1997).

The stainless-steel wire external tag attachment in Figure 3C is better than the rod attachment in Figure 3A and 3B in that it is thinner and there are no rod loops to potentially snag in mesh. However, the circle tag still has the potential to entangle in the mesh. These external tags likely get caught up in the natural environment as well, as evidenced by the two head-started individuals captured that were missing their external tag (with large holes in the marginal scutes where the tag would have been), while retaining their PIT tag. The LDWF discontinued the use of these external tags after we informed them of the two drownings in this study. If the LDWF deems external tags beneficial, a redesign may be necessary to prevent future entanglements and drownings of head-started individuals.

The idea of head-starting vulnerable life stages of turtles in a programmatic way to bolster existing populations or reintroduce them to areas where they have been extirpated is not new, having been around several decades, particularly in sea turtle species (Huff 1989; USFWS and NMFS 1992). Despite their potential, criticisms of head-starting programs abound (Seigel and Dodd 2000). One common criticism is that population persistence is dependent much more on adult survival than it is on younger life stages, and that any available monies that would be spent on head-starting would be better spent protecting adults (Heppell et al. 1996; Burke 2015). A second prominent criticism is that programs like head-starting and captive breeding are not often coupled with programs that address the underlying reasons why a species has declined in the first place (Frazer 1992). Unfortunately, many reintroduction and head-starting programs have not included postrelease assessments of project success, or even defined what success would look like a priori (Seddon et al. 2007; Anthony et al. 2015).

In our study, a minimum of 17% of the released head-started alligator snapping turtles had survived from release until the start of our trapping; we made most captures near where the turtles were released and they exhibited similar or higher growth rates compared to those observed in other studies. This supports the conclusion found by others that most captured releases of head-started alligator snapping turtles were able to acclimate to their new surroundings and secure enough food to grow (Anthony et al. 2015; Moore et al. 2013). A future assessment of this population in 4–5 y, when the cohort will likely attain sexual maturity, could potentially evaluate the usefulness of this head-start program to bolster the wild, breeding alligator snapping turtle population. However, given the observed accidental drownings, it may be best to measure the potential costs of subsequent studies at this site. Methodological interventions, such as checking nets multiple times daily or using thick wire traps, may be warranted to minimize the risk of entanglement-induced mortality.

Supplemental Material

Please note: The *Journal of Fish and Wildlife Management* is not responsible for the content or functionality of any supplemental material. Queries should be directed to the corresponding author for the article.

Data S1. Raw data from turtle trapping survey in Bundick Creek in southwest Louisiana (Beauregard Parish) in 2018. The Louisiana Department of Wildlife and Fisheries provided the release size of recaptured head-started alligator snapping turtles. We show data concerning the location, date, and size of each hoop net as well bait used in each net. We also give raw data concerning the identification, sex, tag numbers, and size measurements of each captured turtle.

Found at DOI: https://doi.org/10.3996/JFWM-20-009.S1 (9 KB ZIP); also available at https://doi.org/10.5066/P9G9BR1D.

Reference S1. Reed RN, Congdon J, Gibbons JW. 2002. The alligator snapping turtle [*Macrochelys* (*Macroclemys*) *temminckii*]: a review of ecology, life history, and conservation, with demographic analyses of the sustainability of take from wild populations. Report to Division of Scientific Authority, United States Fish and Wildlife Service.

Found at DOI: https://doi.org/10.3996/JFWM-20-009.S2 (256 KB PDF); also available at https://srelherp.uga.edu/projects/BobReedAlligatorSnapper-02.pdf.

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Found at DOI: https://doi.org/10.3996/JFWM-20-009.S3 (1.43 MB PDF); also available at https://www.fws.gov/kempsridley/pdfs/kempsrid.pdf.

Acknowledgments

We thank private landowners and hunting lease members for access and assistance in this project. We thank Luke Pearson with guidance on trapping methodology. Animals were captured under Louisiana Department of Wildlife and Fisheries Scientific Collecting Permit LNHP-18-018. All handling of animals was conducted in accordance with approved IACUC protocol USGS/WARC/LFT 2018-02. This article was greatly improved by the reviews of the Associate Editor and three reviewers. This is contribution number 734 of the U.S. Geological Survey Amphibian Research and Monitoring Initiative (ARMI).

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