A trapping survey targeting head-started alligator snapping turtles in southwest Louisiana

Abstract:

The alligator snapping turtle Macrochelys temminckii is the largest freshwater turtle in North America and is sought after as a food source, primarily in Louisiana. Decades of intensive commercial harvest of alligator snapping turtles has been implicated in 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, all alligator snapping turtles were measured, weighed, and marked 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 one week 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. An additional head-started juvenile alligator snapping turtle was captured by a landowner during our trapping and measurements were taken before release. A minimum of 17% of head-started alligator snapping turtles survived since release, and most captured head-started individuals were trapped near their release site and 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 use of external tags was discontinued by the Louisiana Department of Wildlife and Fisheries based on our findings, as they were detrimental to the health of head-started turtles.
A trapping survey targeting head-started alligator snapping turtles in southwest Louisiana

Brad M. Glorioso,* Lindy J. Muse, Cory J. Hillard, Brittany R. Maldonado, Jared Streeter,** Charles D. Battaglia, J. Hardin Waddle

B.M. Glorioso, C.J. Hillard, B.R. Maldonado
U.S. Geological Survey, Wetland and Aquatic Research Center, 700 Cajundome Boulevard, Lafayette, Louisiana 70506

Present address of C.J. Hillard: University of Louisiana at Lafayette, Department of Biology, 410 East Saint Mary Boulevard, Billeaud Hall, Room 108, Lafayette, Louisiana 70503

L.J. Muse
Cherokee Nation Businesses, Wetland and Aquatic Research Center, 700 Cajundome Boulevard, Lafayette, Louisiana 70506

Present address: Southeastern Louisiana University, Biological Sciences, 808 North Pine Street Extension, P.O. Box 10736, Hammond, Louisiana 70402

C.D. Battaglia
Louisiana Department of Wildlife and Fisheries, 200 Dulles Drive, Lafayette, Louisiana 70506

J. Streeter
Louisiana Department of Wildlife and Fisheries, 368 Century Link Drive, Monroe, Louisiana 71203

J. Hardin Waddle
U.S. Geological Survey, Wetland and Aquatic Research Center, 7920 Northwest 71 Street, Gainesville, Florida 32653

* Corresponding author: gloriosob@usgs.gov

** Deceased
Abstract

The alligator snapping turtle *Macrochelys temminckii* is the largest freshwater turtle in North America and is sought after as a food source, primarily in Louisiana. Decades of intensive commercial harvest of alligator snapping turtles has been implicated in 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, all alligator snapping turtles were measured, weighed, and marked 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 one week 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. An additional head-started juvenile alligator snapping turtle was captured by a landowner during our trapping and measurements were taken before release. A minimum of 17% of head-started alligator snapping turtles survived since release, and most captured head-started individuals were trapped near their release site and 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 use of external tags was discontinued by the Louisiana Department of Wildlife and Fisheries based on our findings, as they were detrimental to the health of head-started turtles.

Key words: alligator snapping turtle; Growth; Louisiana; *Macrochelys temminckii*; methodology

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

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):xx-xx; e1944-687X. https://doi.org/10.3996/JFWM-20-009
This Online Early paper will appear in its final typeset version in a future issue of the Journal of Fish and Wildlife Management. This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. The findings and conclusions in this article are those of the author(s) and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

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, little was known 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 years of age in captivity, with less known of wild longevity (Ewert et al. 2006). Alligator snapping turtles have delayed maturity, with reports of 11–13 years to maturity from a sample of 231 Louisiana individuals (Dobie 1971), and 11–21 years 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). A mean clutch size of 35.1 eggs, with a maximum of 52, was recorded 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; Ewert and Jackson 1994; 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). Population declines have now been noted throughout the range, with overharvesting for domestic and international food markets identified 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 known to be 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 United States Fish and Wildlife Service (USFWS) due to insufficient data (USFWS 1984). In 1991, the alligator snapping turtle was formally listed 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-day 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-day finding, the USFWS will issue a 12-month 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). With a valid Basic Resident or Non-Resident Louisiana fishing license, however, any size alligator snapping turtle may still be taken 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 in 2008–2009 in northeast Louisiana. In the
same study area, all 90 monitored artificial alligator snapping turtle nests (used medium-sized chicken eggs as substitute) were depredated, primarily by raccoons *Procyon lotor* and nine-banded armadillos *Dasypus novemcinctus*, with 85.6% of them depredated in the first 24 hours (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). By head-starting alligator snapping turtles in captivity, where growth is accelerated with supplemental food and heating, survival rates upon release are presumed to be 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 were released years prior by the LDWF 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 with respect to trap days, hoop net diameter, and bait type. This information can be used by LDWF managers to gauge the efficacy of this release and inform future releases and monitoring.

**Methods**

Fifty-three head-started juvenile alligator snapping turtles were released at seven sites along an approximately 5.7-km section of Bundick Creek in Beauregard Parish by the LDWF between 18 November 2015 and 26 October 2016 (Figure 1). Bundick Creek is recognized as a Natural and Scenic River by LDWF and is a tributary of another Natural and Scenic River, Whiskey Chitto Creek, which empties into the Calcasieu River. This site was chosen by the LDWF because of its habitat suitability for alligator snapping turtles (sandy-bottomed, flowing creek of varying depths with abundant submerged and downed logs/trees), its remoteness (no motorized boat access), and the cooperation of landowners. This cohort was hatched in 2012 at a Louisiana commercial turtle farm and transferred to a LDWF hatchery in Monroe, Louisiana, in early 2013. All released head-started alligator snapping turtles were assumed to be female due to egg incubation temperatures at the turtle farm. A subset of ten young alligator snapping turtles
was non-destructively examined prior to initial release by a veterinarian using laparoscopy and all were female, supporting the assumption of an all-female cohort. All turtles were measured for midline carapace length and carapace maximum width to the nearest millimeter and weighed to the nearest gram before release by the LDWF. In addition, turtles were marked with both an internal passive integrated transponder (PIT) tag (Biomark HPT12) and an external metal tag, which was etched with a unique identification number along with a LDWF phone number to call if a turtle were captured or found. No prior attempts were made before this study to capture these head-started alligator snapping turtles in Bundick Creek.

We trapped four consecutive nights at each of the seven release sites along Bundick Creek during four weeks between late June and early October 2018. We trapped two release sites concurrently each of the first three weeks 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 (mid-size 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 mid-size 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, the turtle would hopefully 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-m 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 for 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 mm, and mass to the nearest 25 g for each captured alligator snapping turtle. Each turtle was visually checked for an external tag on the back of the carapace and then scanned for a PIT tag. If neither an external tag or PIT tag was detected, we considered the turtle to be native to the creek (not a head-start). 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 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 Chi-square 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 seven species during 16 days of trapping (Glorioso et al. 2019; 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 four were native to the creek (Figure 2). One additional head-started alligator snapping turtle was caught by rod and reel by a landowner and was held 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 1.2–2.7 cm/yr in carapace length and 1.4–2.5 cm/yr in carapace width (Table 2). Mass gain of those seven varied from 0.4–1.2 kg/yr. One individual (ID #102) grew only 0.3 cm/yr in carapace length and 0.5 cm/yr in carapace width, whereas another individual (ID #89) grew only 0.7 cm/yr both in carapace length and width. ID #89 gained only 0.05 kg/yr in mass, whereas ID #102 lost mass since its release nearly two years 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 were captured farthest from their initial release site, with ID #102 captured over 4-km in creek length from its initial release site. All other head-started alligator snapping turtles were captured a mean of 391 m (range = 36–729 m) from their initial release site. One individual (ID #28) was captured on three consecutive days, initially being captured 299 m downstream from its original release site. The next day it was captured 65 m upstream from its previous capture the day prior, and then captured 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 mid-week (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 the two most commonly trapped species were captured in traps in similar proportions with regard to bait type (both $p > 0.8$), alligator snapping turtles were captured more often with cut bait than Gulf Menhaden (11 and 4 captures, respectively), but this difference was not statistically significant ($\chi^2_1 = 3.397, p = 0.065$). Catch per unit effort (CPUE), or turtles per trap night (TTN), 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 ($\chi^2_2 = 10.673, p = < 0.005$; 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 the external tag getting entangled 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 has the turtle identification 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 (Figure 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 snapping turtle captured after the previous deaths, and under advisement of the LDWF, we removed this external tag before release (Figure 3C).

Another turtle (ID #59) also got entangled in the mesh by the loop of the rod attachment, having to be cut free of the net, but 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 three years 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-yr old releases, respectively. However, capture rates were low at 4%, 11%, and 19% for 3, 4, and 5-yr 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 are not available for capture, and others may be in the release area but went uncaptured (imperfect detection).

In its simplest form, catch per unit effort (CPUE) is where catch is directly proportional to both effort and population size (Schaefer 1954). Two general assumptions of using CPUE is 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 turtles are less likely to be captured 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 TTN (Table 5). These low capture rates are often found in areas at the periphery of the species range, or in areas where historical harvest is known or suspected. Though overall CPUE among many sites in some studies is low, individual sites can have much higher CPUEs, perhaps indicating less historical pressure on these populations. For instance, Folt and Godwin (2013) reported a CPUE of 0.478 TTN 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 one year of radio-tracking 12 wild-caught juvenile alligator snapping turtles in north Louisiana, nine of which were determined by laparoscopy to be female. As all nine of our head-started alligator snapping turtles were presumed to be females, a comparison is made 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 those that remained in captivity for the same period in 3 of the 4 years 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/yr. 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 years 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.

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 get snagged. However, the circle tag still has the potential to get entangled 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 being informed of the two drownings in this study. If external tags are deemed beneficial to the LDWF, a re-design 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/head-starting programs have not included post-release 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, and most captures were caught near where they were released and exhibited similar or higher growth rates 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 years, 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. Data concerning the location, date, and size of each hoop net as well bait used in each net is given. Raw data concerning the identification, sex, tag numbers and size measurements of each captured turtle is given.

Found at DOI: [https://doi.org/10.5066/P9G9BR1D](https://doi.org/10.5066/P9G9BR1D).

**Reference S1.** Glorioso BM, Battaglia CD, Streeter J, Waddle JH. 2019. Data from a turtle trapping effort at a release site of head-started alligator snapping turtles, *Macrochelys temminckii*, in southwest Louisiana in 2018: U.S. Geological Survey data release.

Found at DOI: [https://doi.org/10.5066/P9G9BR1D](https://doi.org/10.5066/P9G9BR1D).

**Reference S2.** 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. Division of Scientific Authority, United States Fish and Wildlife Service.

Found at: [https://srelherp.uga.edu/projects/BobReedAlligatorSnapper-02.pdf](https://srelherp.uga.edu/projects/BobReedAlligatorSnapper-02.pdf).
Reference S3. [USFWS and NMFS] U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1992. Recovery plan for the Kemp's ridley sea turtle (Lepidochelys kempi). St. Petersburg, Florida: National Marine Fisheries Service.

Found 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. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government. This is contribution number 734 of the U.S. Geological Survey Amphibian Research and Monitoring Initiative (ARMI).

Any use of trade, product, website, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.
References

Adkins Giese CL, Greenwald DN, Curry T. 2012. Petition to list 53 amphibians and reptiles in the United States as threatened or endangered species under the Endangered Species Act. Center for Biological Diversity. Available: https://www.biologicaldiversity.org/campaigns/amphibian_conservation/pdfs/Mega_herp_petition_7-9-2012.pdf (May 2020).

Anthony T, Riedle JD, East MB, Fillmore B, Ligon DB. 2015. Monitoring of a reintroduced population of juvenile alligator snapping turtles. Chelonian Conservation and Biology 14:43–48.

Boundy J, Kennedy C. 2006. Trapping survey results for the alligator snapping turtle (Macrochelys temminckii) in southeastern Louisiana, with comments on exploitation. Chelonian Conservation and Biology 5:3–9.

Burke RL. 2015. Head-starting turtles: learning from experience. Herpetological Conservation and Biology 10:299–308.

Cagle FR. 1939. A system of marking turtles for future identification. Copeia 1939:170–173.

Congdon JD, Dunham AE, van Loben Sels RC. 1993. Delayed sexual maturity and demographics of Blanding’s turtles (Emydoidea blandingi): implications for conservation and management of long-lived organisms. Conservation Biology 7:826–833.

Congdon JD, Dunham AE, van Loben Sels RC. 1994. Demographics of common snapping turtles (Chelydra serpentina): implications for conservation and management of long-lived organisms. American Zoologist 34:397–408.

Dobie J. 1971. Reproduction and growth in the alligator snapping turtle, Macrolemys temmincki (Troost). Copeia 1971:645–658.

Dorcas ME. 2005. Herpetology laboratory guidelines and protocols. Davidson, North Carolina: Davidson College, Department of Biology.

Dreslik MJ, Carr JL, Ligon DB, Kessler EJ. 2017. Recovery of the alligator snapping turtle (Macrochelys temminckii) in the Mississippi River Valley drainages of southern Illinois, Oklahoma, and Louisiana. Illinois Natural History Survey Technical Report 28. Available: https://www.researchgate.net/publication/320881551_RECOVERY_OF_THE_ALLIGA
East MB, Riedle JD, Ligon DB. 2013. Temporal changes in an alligator snapping turtle
(Macrochelys temminckii) population. Wildlife Research 40:77–81.

[EPA] U.S. Endangered Species Act of 1973, as amended, Pub. L. No. 93-205, 87 Stat. 884
(Dec. 28, 1973). Available at: http://www.fws.gov/endangered/esa-
library/pdf/ESAall.pdf.

Ewert MA. 1976. Nests, nesting and aerial basking of Macrolemys under natural conditions,
and comparisons with Chelydra (Testudines: Chelydridae). Herpetologica 32:150–156.

Ewert MA, Jackson DR. 1994. Nesting ecology of the alligator snapping turtle (Macrolemys
temminckii) along the lower Apalachicola River, Florida. Florida Game and Fresh Water
Fish Commission. Nongame Wildlife Program Report NC89-020. Tallahassee. Available:
https://f50006a.eos-intl.net/ELIBSQL12_F50006A_Documents/94ewert.pdf (May 2020).

Ewert MA, Jackson DR, Moler PE. 2006. Macrochelys temminckii - alligator snapping turtle.
Chelonian Research Monographs 3:58–71.

Folt B, Godwin JC. 2013. Status of the alligator snapping turtle (Macrochelys temminckii) in
south Alabama with comments on its distribution. Chelonian Conservation and Biology
12:211–217.

Folt B, Jensen JB, Teare A, Rostal D. 2016. Establishing reference demography for conservation:
a case study of Macrochelys temminckii in Spring Creek, Georgia. Herpetological
Monographs 30:21–33.

Frazer NB. 1992. Sea turtle conservation and halfway technology. Conservation Biology 6:179–
183.

Frazer NB, Gibbons JW, Greene JL. 1990. Life tables of a slider turtle population. Pages 183–
200 in Gibbons JW, editor. Life history and ecology of the slider turtle. Washington
D.C.: Smithsonian Institution Press.

Glorioso BM, Battaglia CD, Streeter J, Waddle JH. 2019. Data from a turtle trapping effort at a
release site of head-started alligator snapping turtles, Macrochelys temminckii, in
southwest Louisiana in 2018: U.S. Geological Survey data release,
https://doi.org/10.5066/P9G9BR1D (see Supplemental Material, Reference S1).
Haskell A, Graham TE, Griffin CR, Hestbeck JB. 1996. Size related survival of headstarted redbelly turtles (*Pseudemys rubriventris*) in Massachusetts. *Journal of Herpetology* 30:524–527.

Harrel JB, Allen CM, Hebert SJ. 1997. One year growth of subadult *Macroclemys temminckii* in a Louisiana bayou. *Herpetological Review* 28:128–129.

Heppell SS, Crowder LB, Crouse DT. 1996. Models to evaluate headstarting as a management tool for long-lived turtles. *Ecological Applications* 6:556–565.

Holcomb SR, Carr JL. 2011. Hatchling emergence from naturally incubated alligator snapping turtle (*Macrochelys temminckii*) nests in northern Louisiana. *Chelonian Conservation and Biology* 10:222–227.

Holcomb SR, Carr JL. 2013. Mammalian depredation of artificial alligator snapping turtle (*Macrochelys temminckii*) nests in north Louisiana. *Southeastern Naturalist* 12:478–491.

Howey CAF, Dinkelacker SA. 2013. Characteristics of a historically harvested alligator snapping turtle (*Macrochelys temminckii*) population. *Copeia* 2013:58–63.

Huff JA. 1989. Florida (USA) terminates “headstart” program. *Marine Turtle Newsletter* 46:1–2.

Huntzinger CC, Louque I, Selman W, Lindeman PV, Lyons EK. 2019. Distribution and abundance of the alligator snapping turtle (*Macrochelys temminckii*) in southwestern Louisiana. *Southeastern Naturalist* 18:65–75.

Iverson JB. 1991. Patterns of survivorship in turtles (Order Testudines). *Canadian Journal of Zoology* 69:385–391.

King RL, Hepler BP, Smith LL, Jensen JB. 2016. The status of *Macrochelys temminckii* (alligator snapping turtle) in the Flint River, GA, 22 years after the close of commercial harvest. *Southeastern Naturalist* 15:575–585.

Lancia RA, Bishir JW, Conner MC, Rosenberry CS. 1996. Use of catch-effort to estimate population size. *Wildlife Society Bulletin* 24:731–737.

[LDWF] Louisiana Department of Wildlife and Fisheries. 2020. Louisiana 2020 Fishing Regulations. Baton Rouge. Available: [http://www.eregulations.com/wp-content/uploads/2019/12/20LAFW_LR.pdf](http://www.eregulations.com/wp-content/uploads/2019/12/20LAFW_LR.pdf) (May 2020).

Moore DB, Ligon DB, Fillmore B, Fox SF. 2013. Growth and viability of a translocated population of alligator snapping turtles (*Macrochelys temminckii*). *Herpetological Conservation and Biology* 8:141–148.
Moore DB, Ligon DB, Fillmore B, Fox SF. 2014. Spatial use and selection of habitat in a reintroduced population of alligator snapping turtles (*Macrochelys temminckii*). The Southwestern Naturalist 59:30–37.

Pritchard PCH. 1979. ‘Head-starting’ and other conservation techniques for marine turtles Cheloniidae and Dermochelyidae. International Zoo Yearbook 19:38–42.

Pritchard PCH. 1989. The Alligator Snapping Turtle: Biology and Conservation. Wisconsin: Milwaukee Public Museum.

Pritchard PCH. 2006. The Alligator Snapping Turtle: Biology and Conservation. 2nd edition. Malabar, Florida: Krieger Publishing Company.

Reed RN, Congdon J, Gibbons JW. 2002. The alligator snapping turtle [*Macrochelys* (*Macrolemys*) *temminckii*]: A review of ecology, life history, and conservation, with demographic analyses of the sustainability of take from wild populations. Division of Scientific Authority, United States Fish and Wildlife Service. Available: [https://srelherp.uga.edu/projects/BobReedAlligatorSnapper-02.pdf](https://srelherp.uga.edu/projects/BobReedAlligatorSnapper-02.pdf) (May 2020) (see Supplemental Material, Reference S2).

Riedle JD, Shipman PA, Fox SF, Leslie DM Jr. 2005. Status and distribution of the alligator snapping turtle, *Macrochelys temminckii*, in Oklahoma. The Southwestern Naturalist 50:79–84.

Riedle JD, Ligon DB, Graves K. 2008. Distribution and management of alligator snapping turtles, *Macrochelys temminckii*, in Kansas and Oklahoma. Transactions of the Kansas Academy of Science 111:21–28.

Rittenhouse CD, Millspaugh JJ, Hubbard MW, Sheriff SL. 2007. Movements of translocated and resident three-toed box turtles. Journal of Herpetology 41:115–121.

Schaefer MB. 1954. Some aspects of the dynamics of populations important to the management of commercial marine fisheries. Bulletin of the Inter-American Tropical Tuna Commission 1:25–56.

Seddon PJ, Armstrong DP, Maloney RF. 2007. Developing the science of reintroduction biology. Conservation Biology 21:303–312.

Seigel RA, Dodd CK Jr. 2000. Manipulation of turtle populations for conservation: halfway technologies or viable options? Pages 218–238 in Klemens MW, editor. Turtle conservation. Washington D.C.: Smithsonian Institution Press.
Sloan K, Lovich J. 1995. Exploitation of the alligator snapping turtle, *Macrolemys temminckii*, in Louisiana: a case study. Chelonian Conservation Biology 1:221–222.

[USFWS] U.S. Fish and Wildlife Service. 1984. Endangered and threatened wildlife and plants; finding on a petition to list the alligator snapping turtle as a threatened species. Federal Register 49:7416–7417.

[USFWS] U.S. Fish and Wildlife Service. 1991. Endangered and threatened wildlife and plants: animal candidate review for listing as endangered or threatened species, proposed rule. Federal Register 56:58804–58836.

[USFWS] U.S. Fish and Wildlife Service. 2015. Endangered and threatened wildlife and plants: 90-day findings on 31 petitions. Federal Register 80:37568–37579.

[USFWS and NMFS] U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1992. Recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempi*). St. Petersburg, Florida: National Marine Fisheries Service. Available: https://www.fws.gov/kempsridley/pdfs/kempsrid.pdf (May 2020) (see Supplemental Material, Reference S3).
Table Captions

Table 1. Total turtles captured in all trapping periods at Bundick Creek in southwest Louisiana (Beauregard Parish) in 2018. All head-started alligator snapping turtles *Macrochelys temminckii* were assumed to be female but are not included in the table below due to uncertainty, nor were 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.

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

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

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. Trap nights (TN) is given in the column header, with the number of captures by species in parentheses.

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.
Figure Captions

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

**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.

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

**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. All nine captured head-started juveniles in this study were presumed to be female and were compared with the nine wild-caught juvenile females in Harrel et al. (1997).
| 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 *Graptemys 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               |
| ID | Date       | Site | Release Date | Site | Carapace Length | Recapture Date | Site | Carapace Width | Growth Rate | Mass | At Release | At Recap | Growth Rate |
|----|------------|------|--------------|------|-----------------|----------------|------|----------------|-------------|------|------------|----------|-------------|
| 21 | 18-Nov-15  | D    | 14-Aug-18    | D    | 2.74            | 25.6           | 30.8 | 1.9            | 22.6        | 27.6 | 1.8        | 4.921    | 7.500       |
| 28 | 18-Nov-15  | C    | 14-Aug-18    | C    | 2.74            | 24.6           | 27.8 | 1.2            | 21.8        | 26.1 | 1.6        | 3.964    | 6.100       |
| 53 | 3-Aug-16   | E    | 26-Jun-18    | F    | 1.90            | 22.5           | 26.1 | 1.9            | 21.0        | 24.4 | 1.8        | 3.400    | 4.500       |
| 59 | 26-Oct-16  | F    | 29-Jun-18    | E    | 1.67            | 21.5           | 26.0 | 2.7            | 19.0        | 23.1 | 2.4        | 2.854    | 4.900       |
| 73 | 26-Oct-16  | G    | 27-Jun-18    | G    | 1.67            | 22.2           | 26.0 | 2.3            | 20.2        | 24.3 | 2.5        | 2.912    | 4.550       |
| 82 | 3-Aug-16   | E    | 26-Jun-18    | E    | 1.90            | 18.7           | 21.4 | 1.4            | 16.5        | 19.1 | 1.4        | 1.864    | 2.700       |
| 89a| 3-Aug-16   | A    | 28-Jun-18    | F    | 1.90            | 19.9           | 21.2 | 0.7            | 17.6        | 18.9 | 0.7        | 2.200    | 2.300       |
| 102a| 3-Aug-16  | F    | 14-Aug-18    | D    | 2.03            | 17.8           | 18.4 | 0.3            | 15.5        | 16.5 | 0.5        | 1.486    | 1.375       |
| 114| 26-Oct-16  | F    | 26-Jun-18    | E    | 1.67            | 21.2           | 23.8 | 1.6            | 18.7        | 21.9 | 1.9        | 2.242    | 3.150       |

*Refers to individuals drowned by getting external tag caught in hoop net*
| 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 *Graptemys 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             |
| Species                                           | Total Captures | 1.22 m Hoop Nets (144 TN) | 0.91 m Hoop Nets (84 TN) | 0.76 m Hoop Nets (40 TN) |
|--------------------------------------------------|----------------|---------------------------|--------------------------|--------------------------|
| Alligator snapping turtle *Macrochelys temminckii* | 15             | 0.063 (9)                 | 0.060 (5)                | 0.025 (1)^a              |
| 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 *Graptemys 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 refers to alligator snapping turtle tangled on outside of net
| 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                 |
Response to Reviewers.

JFWM Response to Reviewers.docx

Click here to access/download