Relative Abundance, Growth, and Mortality of the White Catfish, *Ameiurus catus* L., in the St. Marys River

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Abstract - Declines in *Ameiurus catus* (White Catfish) abundance throughout much of their native range have been attributed to the rapid colonization of invasive *Ictalurus furcatus* (Blue Catfish) and *Pylodictis olivaris* (Flathead Catfish). Because of the potential for imperilment throughout a majority of its native range, we examined the White Catfish population in the St. Marys River, GA, one of the few locations where the catfish assemblage is still native. White Catfish (n = 1244) dominated the ictalurid assemblage, making up 79% of the catfish caught in the St. Marys River. Overall, length of White Catfish varied from 89 to 486 mm TL, with the majority of fish between 220 and 260 mm. Ages of White Catfish varied from 1 to 11 years but was dominated by the 2012 year class (age 3). We estimated a von Bertalannfy growth model for the population (L_∞ = 486 mm TL, K = 0.246, t_0 = -0.290). Catch-curve analysis indicated that White Catfish had a 45% annual survival rate in 2015. This White Catfish population assessment will provide biologists with baseline parameters to aid in future management and conservation of this declining native species.

Introduction

Ameiurus catus (L.) (White Catfish) is a freshwater bullhead catfish species that is native to Atlantic Coastal drainages extending from New York to Florida and west to the Apalachicola basin in Florida, Georgia, and Alabama (Boschung and Mayden 2004). White Catfish are omnivores with diets consisting of various insects (e.g., midges, scuds, and mayflies), fish, detritus, and pondweed (Boschung and Mayden 2004, Crumpton 2000). White Catfish inhabit low-velocity, mud-bottomed pools, open channels, and backwaters of small to large rivers, and also occur in tidal waters with salinities up to 5 ppt (Boschung and Mayden 2004). The White Catfish has been widely introduced in systems outside of its native distribution, throughout the United States and on other continents (Britton and Davies 2006, US Geological Survey 2017).

Life-history data are very limited for the White Catfish, particularly for populations in the species' native range. Schwartz and Jachowski (1965) used vertebrae to age White Catfish, documenting ages up to 12 years for specimens from the Patuxent River, MD, and up to 14 years in a Maryland millpond population. Hughes and Carlson (1986) used pectoral spines to estimate the ages of White Catfish from the Hudson River Estuary, NY, with the majority of fish between 4 and 7 years old (max age = 8 yrs). In a follow-up study, White Catfish with ages up to 14 years were documented in the Hudson River Estuary population (Jordan et al. 2004). Crumpton

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(1999) also used pectoral spines to age White Catfish from the Clermont Chain of Lakes, FL, with ages of fish varying from 2 to 7 years. Unfortunately, pectoral spines may underestimate the ages of older catfish (Barada et al. 2011, Maceina and Sammons 2006, Nash and Irwin 1999), and otoliths typically provide more accurate and precise age estimates than pectoral spines for some ictalurid species (Barada et al. 2011, Buckmeier et al. 2002, Khan et al. 2013, Maceina and Sammons 2006, Maceina et al. 2007). Keller (2011) used lapillar otoliths to estimate ages of White Catfish in the Delaware River Estuary and documented fish up to 14 years old.

Rapid declines in population abundances of small-bodied native catfishes along the Atlantic Coastal Plain have occurred quickly following the introduction of large nonnative piscivorous catfish. Invasive *Ictalurus furcatus* (Valenciennes in Cuvier and Valenciennes) (Blue Catfish) and *Pylodictis olivaris* (Rafinesque) (Flathead Catfish) have been implicated in these population declines (Bonvechio et al. 2009, Brown et al. 2005, Guier et al. 1984, Homer and Jennings 2011, Kaeser et al. 2011, Kwak et al. 2006, Moser and Roberts 1999, Sakaris et al. 2006, Thomas 1995). More specifically, population declines of several *Ameiurus* spp. (bullhead catfishes) have been documented in the past several decades (Cailteux and Dobbins 2005, Dobbins et al. 2012, Guier et al. 1984, Homer and Jennings 2011, Thomas 1995). For example, Homer and Jennings (2011) reported a relatively immediate, negative influence of introduced Blue Catfish in the Oconee River system, GA, as native White Catfish abundances declined with concurrent growth and expansion of the Blue Catfish population.

Few White Catfish populations remain unaltered by rapidly expanding invasive catfishes along the Atlantic Coastal Plain. In addition, White Catfish populations that continue to dominate the ictalurid community are rare and include populations that reside in the St. Johns River in Florida (Jay Holder, Florida Fish and Wildlife Conservation Commission, DeLeon Springs, FL, pers. comm.), the Ogeechee River (Tim Barrett, Georgia Department of Natural Resources [GADNR], Richmond Hill, GA, pers. comm.) and the St. Marys River of Georgia (current study), the Delaware River Estuary (Keller 2011), and the New, Newport, and White Oak rivers in North Carolina (Davis and McCoy 1965, Rachels and Ricks 2016). Considering the long history of persistently expanding Flathead Catfish populations (i.e., since the 1950s; Quinn 1987) and more recently the establishment and growth of Blue Catfish populations in the southeastern Georgia rivers (Bonvechio et al. 2012), the introduction of these nonnative predators and their further expansion throughout coastal plain river systems may ultimately occur. Therefore, assessment of native catfish populations before invasions would inform management decisions, providing managers with baseline population data that may be used to evaluate and monitor effects of a future invader. In the event of an invasion, managers may decide to institute an invasive species removal program to minimize the effects of the nonnative predator on native fauna in the system (Bonvechio et al. 2011a, b). Accordingly, we aimed to assess a native catfish assemblage, not currently affected by an invasive species, in the St. Marys River, GA. Our specific objectives were to estimate the relative abundances of all catfishes present in river, as well as describe the age, growth, and mortality of the most abundant species, the White Catfish.

Field-Site Description

The headwaters of the St. Marys River originate in the Okefenokee swamp in Charlton County, GA. It flows southward, eastward for a short stretch, northward, and then eastward again forming the Florida–Georgia State border. The St. Marys River watershed is located in Georgia and Florida and drains ~3367 km^2, with ~1981 km^2 of drainage in Georgia (GADNR EPD 2002). The St. Marys River runs for 230 km before it empties into the Atlantic Ocean near the city of St. Marys, south of Cumberland Island (GADNR EPD 2002). Although 52 species of fish (17 families) reside in the St. Marys basin, fish populations are limited in productivity by acidic waters, low alkalinity, and large fluctuations in river flows (GADNR EPD 2002). Historical discharge of the St. Marys has fluctuated widely from 22 to 4520 m^3/s with a mean annual discharge of 779 m^3/s (US Geological Survey, MacClenney, FL, gauge). We chose 6 fixed standardized sampling locations, with the upper most sampling station upstream of the Traders Hill boat ramp located at river kilometer 89 (30°45'23"N, 82°01'07"W) and the lowest station occurring downstream of the Camp Pickney boat ramp at approximately river kilometer 31 (30°46'44"N, 82°47'19"W).

Methods

Field sampling

We conducted catfish sampling using low-amperage, pulsed DC electrofishing (200–1000 volts at 18 pulses per sec. and >1 amp of output) during daylight hours in a downstream direction from a 5.1-m aluminum jon boat. We used Smith-Root© electrofishing backpack shock boxes, following sampling procedures described in previous research studies conducted by GADNR (Bonvechio et al. 2011, 2016; Thomas 1995). A chase boat was also deployed in an effort to increase capture efficiency (Cunningham 2004, Daugherty and Sutton 2005). Sampling occurred over 3 field days between 28 July and 5 August 2015 when water temperatures exceeded 27 °C and water levels were well within the banks of the river. We sampled each transect (n = 6) for 1 hr to calculate a relative index of abundance (fish/hr). All catfish were measured to the nearest mm (total length [TL]) and weighed to the nearest 0.1 g. We obtained a White Catfish age analysis subsample (n = 184) using 5 fish per 1-cm group up to 350 mm TL and all fish ≥350 mm TL. Retained fish were place on ice and returned to the lab for measurements, determination of sex, and extraction of lapilli otoliths (Long and Stewart 2010).

Aging methods

We lightly browned otoliths from the collected fish on a hotplate to improve the clarity of annuli (i.e., annular growth rings; Buckmeier et al. 2002). Otoliths were then embedded in a clear epoxy resin and sectioned along a transverse plane with a high-precision, low-speed diamond sectioning saw (Preciso, Model CL-40). Each otolith was sectioned only once at the core, and then glued with Crystal Bond in a position perpendicular to the plane of a microscope slide (Buckmeier et al. 2002). If necessary, we polished otolith sections with ultra-fine (1500-grit) sandpaper to further enhance the clarity of annuli. Otolith sections were viewed under a dissecting microscope, illuminated with a fiber optic light source. Similar to Steuk and Schnitzler (2011), 2 independent experienced readers estimated the age of each fish, and differences in age between readers were reconciled by a third experienced reader.

Data analyses

We constructed an age–length key from the aged fish and extrapolated to the entire sample (Ricker 1975). The instantaneous (Z) and total (A) rates of annual mortality were estimated for age-2 and older fish using weighted catch-curve regression in the Fishery Analysis and Modeling Simulator Software (FAMS; Slipke and Maceina 2014, Smith et al. 2012). We also fit a von Bertalanffy growth model (Ricker 1975) for the White Catfish population using FAMS. Mean total length at age was used to compute the growth curve, and growth was not extrapolated past the maximum age obtained in the sample (age 11). Sexes were combined for all mortality and growth estimates. All models were considered significant at $\alpha = 0.05$.

Results

Abundance and assemblage

White catfish (n = 1244) dominated the ictalurid community, making up 79% of the catfish assemblage, followed by *Ictalurus punctatus* (Rafinesque) (Channel Catfish; n = 282 [18%]), *Ameiurus natalis* (Lesueur) (Yellow Bullhead; n = 42 [2.7%]), and *Ameiurus nebulosus* (Lesueur) (Brown Bullhead; n = 5 [0.3%]). Mean CPE for White Catfish was 209.2 fish/hr (SE = 12.0), followed by Channel Catfish at 47.4 fish/hr (8.7), Yellow Bullhead at 7.1 fish/hr (4.8,) and Brown Bullhead at 0.8 fish/hr (0.2).

White Catfish population characteristics

White Catfish total lengths varied from 89 to 486 mm, with the majority of fish between 220 and 260 mm and a mean length of 249 mm (Fig. 1). Mean relative weight was 86, with lower condition observed among larger fish, especially above 30 cm (Fig. 1). Of the 184 fish collected for age estimation, 67 were females and 72 were males. Forty-five fish were deemed immature, and we could not determine their sex. As a result, the sex ratio for the age sample did not significantly deviate from 1:1 ($\chi^2 = 0.18$, $P = 0.67$). Fecundity estimates were not calculated for females due to the majority of ovaries already appearing spent.

Age, growth, and survival

Only 1 otolith section was considered unreadable and was removed from the age sample. Initial reader agreement between the 2 readers was 73.8% (135/183). Of the 48 disagreements, 40 only differed by 1 year (40/48 [83%]). The majority of disagreements were resolved by the third reader, resulting in final ages estimated for

97.8% of the sample (179/183). Ages of White Catfish varied from 1 to 11 years, but was dominated by a 2012 year class (age 3; Fig. 2). We computed a von Bertalanffy growth model (L_∞ = 486 mm TL, K = 0.246, t_0 = -0.290) for the population (r^2 = 0.94,

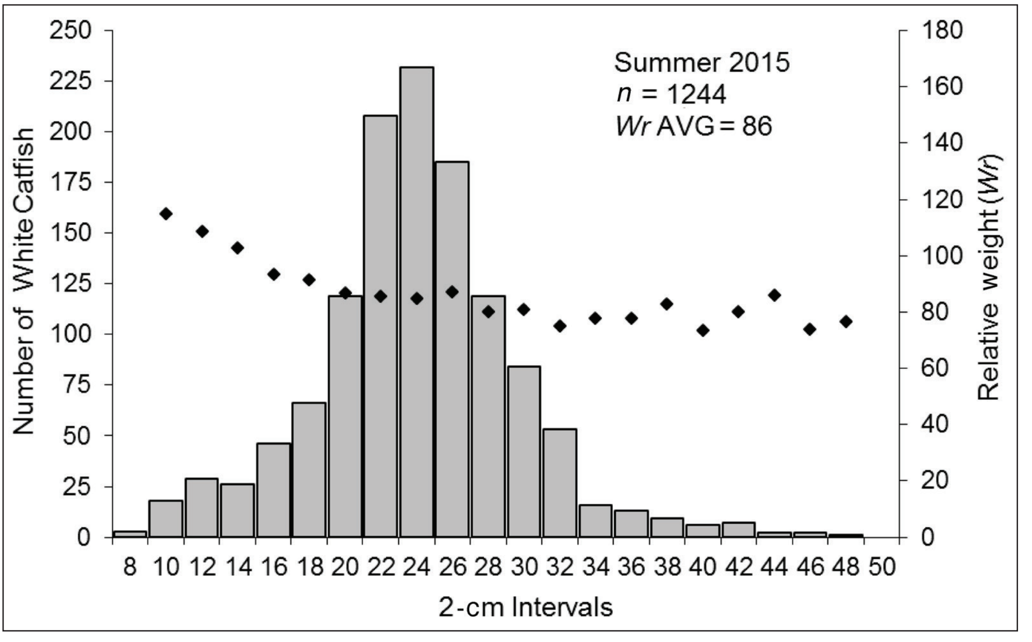

Figure 1. Double axis length–frequency distributions (2-cm bins; shaded bars) and mean relative weights (*Wr*; solid diamonds) of White Catfish collected from the St. Marys River, GA, in 2015.

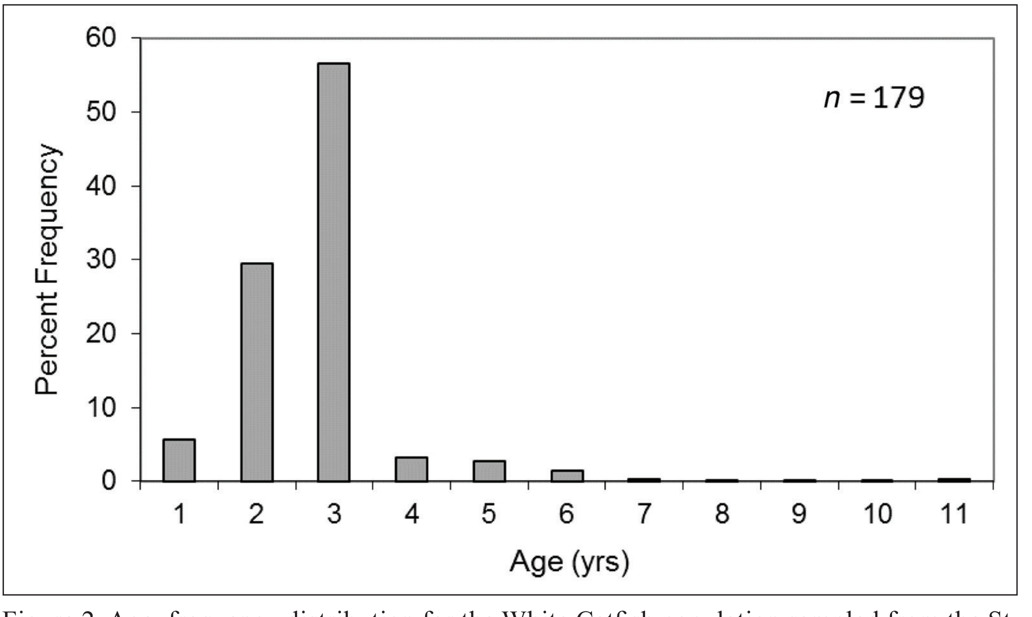

Figure 2. Age–frequency distribution for the White Catfish population sampled from the St. Marys River, GA, in Summer 2015.

P < 0.01; Fig. 3), with White Catfish reaching mean total lengths of 270, 383, and 437 mm at ages 3, 6, and 9, respectively. Catch-curve analysis indicated that White Catfish exhibited a 45% annual survival rate (*Z* = - 0.80, *P* < 0.01; Fig. 4).

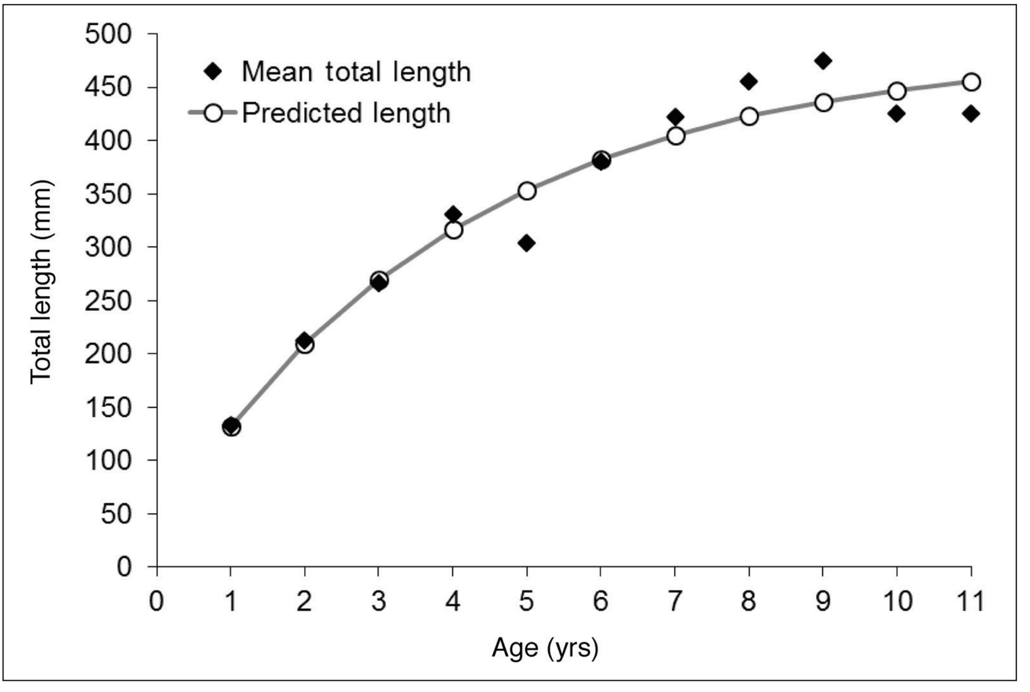

Figure 3. Von Bertalanffy growth curve for White Catfish from the St. Marys River, GA (diamond symbol = mean total length from age sample; open symbol = predicted length from growth model).

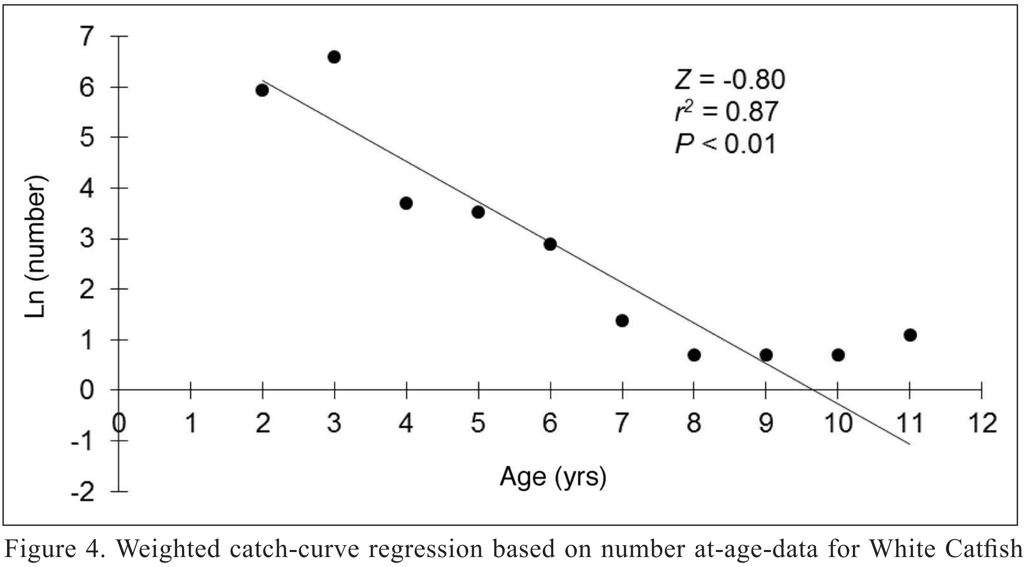

Figure 4. Weighted catch-curve regression based on number at-age-data for White Catfish collected during electrofishing on the St. Marys River in summer 2015 (*n* = 1244).

Discussion

Nonnative Flathead Catfish and Blue Catfish have rapidly expanded throughout several Atlantic Coastal drainages in the Southeast, leading to a decline in native species (Bonvechio et al. 2009, Brown et al. 2005, Grabowski et al. 2004, Grist 2002, Homer and Jennings 2011, Kwak et al. 2006, Sakaris et al. 2006, Thomas 1995). Several native bullhead species have been affected in the Southeast by nonnative introductions. The rapid expansion of the Flathead Catfish in the Appalachicola River, FL, has been implicated as a significant factor to declines in the native *Ameiurus serracanthus* (Yerger and Relyea) (Spotted Bullhead; Cailteux and Dobbins 2005). In the Chesapeake Bay region, substantial declines in the native White Catfish have coincided with rapid range expansions of Blue Catfish (Schloesser et al. 2011). More recently, Homer and Jennings (2011) reported a relatively immediate decline in native White Catfish with a concurrent increase in the Blue Catfish population in Lake Oconee, GA. In the St. Marys River, we documented a highly abundant White Catfish population that continues to dominate the catfish assemblage, showing resiliency and remarkable longevity in this system (maximum age = 11) despite a 55% annual mortality rate. No nonnative catfish were found in the St. Marys River during this study. With the close proximity of the St. Marys River to other systems that are currently influenced by invasive predators (e.g., Satilla River; Bonvechio et al. 2009, 2012), biologists should closely monitor the St. Mary's native catfish assemblage to detect any early signs of an invasion. Early detection, rapid response, and removal of potential invaders is vital to protecting and sustaining native fish assemblages.

Although White Catfish can reach maximum lengths around or exceeding 500 mm TL, our longest individual measured 486 mm TL, which was shorter than a 534-mm fish that was recently found in the White Oak River, NC (Rachels and Ricks 2016). Keller (2011) observed a specimen measuring 520 mm TL from the Delaware River Estuary area. The majority of White Catfish collected from the Hudson River Estuary were less than 500 mm TL (Hughes and Carlson 1986, Jordan et al. 2004). White Catfish grew reasonably fast in the St. Marys River, with growth rates exceeding those observed in the Hudson River Estuary population (213–233 mm TL at age 3 and 339–349 mm TL at age 6; Hughes and Carlson 1986, Jordan et al. 2004), the Patuxent River population (185 mm TL at age 3 and 266 mm TL at age 6; Schwartz and Jachowski 1965), and the Delaware River Estuary population (216 mm TL at age 3 and 309 mm TL at age 6; Keller 2011). The faster growth observed in our population could simply be attributed to a longer growing season in the southern extent of their native distribution. Growth of White Catfish in the St. Marys River was intermediate to growth rates of fish observed in the Clermont Chain of Lakes and St. John's River, FL (Crumpton 2000).

Despite their reasonably fast growth, White Catfish (>200 mm TL) exhibited somewhat poor body condition in the St. Marys River. Typically, fish with relative weights between 95 and 105 are considered to be in good condition (Pope and Cruse 2007). Similar to Rachels and Ricks' (2016) observations of White Catfish from brackish rivers in North Carolina, salinity variation could be influencing White Catfish condition due to the increased energetic demand of osmoregulation and anabolism (Lagler et al. 1962, Pauly 1979). In addition, we conducted sampling soon after the spawning period, which begins in late May or early June (Boschung and Mayden 2004). Adult fish were likely replenishing energy reserves at the time of sampling, while smaller, immature fish maintained good body condition.

Our annual mortality estimate (55%) for White catfish is quite similar to estimates reported for other bullhead catfishes. *Ameiurus brunneus* Jordan (Snail Bullhead) exhibited annual mortality rates of 60.2% (2007) and 56.1% (2010) in Nickajack Creek, a tributary of the Chattahoochee River, GA (Sakaris et al. 2011). Annual mortality can be as high as 79% for bullhead catfish (*Ameiurus melas* (Rafinesque) [Black Bullhead]; Mork et al. 2009). Sakaris et al. (2011) reported that Snail Bullhead were very abundant, with CPUE's up to 205.2 fish/hr, and suggested that mortality was density-dependent in Nickajack Creek. A similar effect of population density on mortality may be occurring for White Catfish in the St. Marys River. Although our mortality rate may have been slightly overestimated due to the presence of a strong (age 3) recruitment class, we contend that higher mortality was more of a consequence of high population density in the system. Mean CPUE for White Catfish in the St. Marys River (209.2 fish/hr) was substantially higher than the CPUE reported for White Catfish in the White Oak River, NC (63.1 fish/hr; Rachels and Ricks 2016). Like White Catfish in the St. Marys, the White Catfish population in the White Oak River, NC, is not currently believed to be influenced by an invasive piscivore. The White Catfish catch rates in the St. Marys are much higher than electrofishing catch rates of White Catfish on the Satilla River (T.F. Bonvechio, unpubl. data), where Flathead catfish have been present since the mid 1990s. In the Satilla River, White Catfish CPUE from 2007 to 2015 has averaged only 16.7 fish/hr over the 9-yr time series. Despite the findings above, life-history and general population data for bullhead catfishes are still very limited in the literature, and more research on the dynamics of bullhead catfish populations is needed.

Age, growth, and life-history parameters of White Catfish are presented in this study and should aid management and future conservation of this species. Nevertheless, a comprehensive study of White Catfish populations across the species' distribution is needed to properly develop species management recommendations. Although the mechanisms as to why White Catfish and other native bullhead catfish suffer drastic declines in abundance when invasive predators become established in a system is unknown (Homer and Jennings 2011), future studies on unaffected native populations are needed and should be pursued whenever possible.

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