Assessment of Tar River catfish populations, 2020

Federal Aid in Sport Fish Restoration
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Abstract. Ictalurids in the Tar River were surveyed using boat-mounted electrofishing in summer 2020. Field staff collected 383 Flathead Catfish, 61 Channel Catfish, 10 White Catfish, and 3 Blue Catfish from 55 sample sites. Flathead Catfish catch per unit effort (CPUE) was 27.0 fish/h at low frequency electrofishing (LFE) sites, Channel Catfish CPUE was 6.0 fish/h at high frequency electrofishing (HFE) sites, White Catfish CPUE was 0.5 fish/h at LFE sites, and Blue Catfish CPUE was 0.2 fish/h at LFE sites. The majority of Flathead Catfish were quality-length followed by preferred-, memorable-, and trophy-lengths. Channel Catfish were predominantly quality-length followed by preferred-length fish. Body condition (W_r) of Flathead Catfish and Channel Catfish indicated adequate forage availability and a lack of density dependent growth. Flathead Catfish annual mortality (*A*) calculated using a Beverton-Holt length-based mortality estimator was 22%. Channel Catfish ages ranged from age 0 to age 8. White Catfish abundance was low, and other bullhead catfishes were not observed. The low abundance of native ictalurids is likely due to the competition of and predation from the robust Flathead Catfish population in the Tar River. Flathead Catfish exploitation is quite low despite the popularity of catfish angling in the Tar River. Low Flathead Catfish exploitation indicates minimal fishing activity impacts in the Tar River. Future surveys should investigate the distribution of ictalurids in the Tar River and continue monitoring non-native catfish effects on resident fish communities.

The Tar-Pamlico watershed is the fourth largest in North Carolina, encompassing 14,090 km^2 (Homan et al. 2006). The portion of the river upstream of U.S. Highway 17 in Washington, NC, is predominantly freshwater, designated as inland waters, and considered the Tar River. The reach below Washington, NC, is designated as coastal waters, referred to as the Pamlico River, and has the characteristics of an upper estuary (Homan et al. 2006). The Tar River supports a recreationally important freshwater resident fish assemblage including Largemouth Bass *Micropterus salmoides*, Channel Catfish *Ictalurus punctatus*, Flathead Catfish *Pylodictis olivaris,* Flier *Centrarchus macropterus*, Redbreast Sunfish *Lepomis auritus*, Green Sunfish *L. cyanellus*, Pumpkinseed *L. gibbosus*, Warmouth *L. gulosus*, Bluegill *L. macrochirus*, Redear Sunfish *L. microlophus*, and Black Crappie *Pomoxis nigromaculatus*. Additionally, anadromous fish species including Alewife *Alosa pseudoharengus*, American Shad *A. sapidissima*, Blueback Herring *A. aestivalis*, Hickory Shad *A. mediocris*, and Striped Bass *Morone saxatilis* use inland waters of the Tar River during spring spawning migrations (Homan et al. 2006).

Catfish are among the most targeted fish species for North Carolina recreational anglers. According to the U.S. Fish and Wildlife Service (USFWS) fishing, hunting, and wildlife-associated recreation national survey, 30% of the total freshwater angling effort in North Carolina is targeted toward catfish species, second only to black bass (USFWS 2012). The Tar River, historically, contained several native catfish species, including Brown Bullhead *Ameiurus nebulosus*, Carolina Madtom *Noturus furiosus*, White Catfish *Ameiurus catus*, and Yellow Bullhead *Ameiurus natalis* (Smith and Bayless 1964; NCWRC, unpublished data). Channel Catfish were introduced into the Tar River in the early 1900s, but this species has since been considered naturalized (Evermann and Cox 1895). Flathead Catfish became established in the Tar River in the 1990s and this population is now thriving (Rachels and Ricks 2018). Blue Catfish *Ictalurus furcatus* were first observed in summer catfish surveys in 2010, and to date, abundances are still low although population expansion is occurring (Rachels and Ricks 2018).

In 2019, the North Carolina Wildlife Resources Commission (NCWRC) designated native catfish species including Black Bullhead *Ameiurus melas*, Brown Bullhead, Flat Bullhead *Ameiurus platycephalus*, Snail Bullhead *Ameiurus brunneus*, White Catfish, and Yellow Bullhead as game fish in inland waters (NCWRC 2019). Additionally, a daily creel limit for bullhead catfishes of 10 fish in combination throughout all inland fishing waters was established. Also, the USFWS designated the Carolina Madtom as a federally endangered species on July 9, 2021 (USFWS 2021). Introduced catfish species including the Blue Catfish, Channel Catfish, and Flathead Catfish are all found in the Tar River with Channel Catfish designated as nongame fish and both Blue Catfish and Flathead Catfish designated as invasive nongame fish (NCWRC 2019). As part of the NCWRC Catfish Management Plan, there are no size or bag limits for Blue Catfish, Channel Catfish, or Flathead Catfish and these fish may be taken using hook and line, grabbling, trotlines, set-hooks, jug-hooks, archery, and special devices such as fish traps, bow nets, and seines in the Tar River.

Since Flathead Catfish became established in the Tar River, observations of native catfishes have become rare (NCWRC, unpublished data). Flathead Catfish are considered an apex piscivore (Borawa 1983; Guier et al. 1984; Baumann and Kwak 2011). Because their diet is comprised primarily of fish, there is concern that predation from Flathead Catfish negatively impacts native fish populations including species of conservation concern such as the Alewife,

American Shad, Blueback Herring, Carolina Madtom, and Striped Bass. Blue Catfish and Channel Catfish are known to consume a variety of other food items besides fish, and their direct impact on the native fish community may not be to the same extent as Flathead Catfish (Wellborn 1988; Graham 1999).

Fishing for Flathead Catfish has become increasingly popular on the Tar River and other coastal North Carolina rivers since their introduction. As a result of the observed increase in fishing pressure, many anglers perceive a need for protective harvest regulations for the Flathead Catfish population. In 2012, 31% of surveyed anglers believed North Carolina catfish regulations were not restrictive enough (Responsive Management 2012). However, in 2016, high abundance and low mortality of Flathead Catfish was observed in the Tar River which indicated that the Flathead Catfish populations was robust and thriving (Rachels and Ricks 2018). Additionally, the competition with and predation on native catfish and other fish species by Flathead Catfish are a conservation concern; therefore, promoting angler harvest of Flathead Catfish is warranted. The objective of this survey was to describe the Tar River catfish populations and note changes in population characteristics over time.

Methods

Study site. From July 13, 2020, to August 6, 2020, catfish were surveyed using a boat-mounted electrofishing unit (Smith-Root 7.5 GPP; one dip netter) at 55 1-km sample sites during daylight hours. The sample area included the 115-km reach of the Tar River from Tarboro to Washington, NC (Figure 1).

Field collection. Low frequency electrofishing (LFE), 2-3 amps and 15-Hz pulsed DC waveform was used at 32 sites (Table 1). Additionally, a chase boat with one dip netter was used for LFE sites to capture catfish. High frequency electrofishing (HFE), 5-7 amps with a 120-Hz pulsed DC waveform was used at 23 sites (Table 2). All catfish were collected while sampling each site. Electrofishing effort (seconds), water temperature (°C), oxygen saturation (%), dissolved oxygen (mg/L), conductivity (µS/cm), and salinity ($^{0}/_{00}$) were recorded for each sample site using a Pro2300 YSI meter (Table 3). Following collection, fish were identified to species, enumerated, total length measured (mm), and weighed (g) prior to release. Channel Catfish and Blue Catfish were sacrificed for sagittal otolith extraction and age determination. A Trimble Yuma field computer was used to record data during sampling events.

Otolith ageing. Once field collection was complete, each otolith was cleaned by removing organics, dipped in sodium hydroxide, dried, and mounted on individual glass microscope slides using a crystal bond adhesive. A hot plate was used to heat the adhesive prior to mounting each otolith. Once the adhesive hardened, each otolith was sectioned using a grinding stone. Next, each otolith was polished using wet 400, 600, and 800 grit sandpaper. Finally, each otolith was read by two readers under a dissecting microscope by covering the otolith with microscope emersion oil and using a fiber optic light. Any discrepancies between the two readers were resolved with a third read in concert.

Data analyses. Relative abundance of each species was indexed as catch per unit effort (CPUE; fish/h). CPUE was calculated separately by species and electrofishing setting due to species differences in sampling efficiency between HFE and LFE (Bodine et al. 2013). Size-structure was evaluated with length-frequency distributions (25-mm size-classes) and

Proportional Stock Density (PSD) length-frequency indices (Anderson 1976; Anderson and Weithman 1978; Wege and Anderson 1978; Anderson 1980; Gabelhouse 1981; Gabelhouse 1983). Relative weight (W_r) was used to assess condition of individuals based on standard weight equations for Flathead Catfish (Bister et al. 2000) and for Channel Catfish (Brown et al. 1995). The Beverton-Holt length-based mortality estimator was used to estimate total instantaneous mortality (Z) for Flathead Catfish using Program R (Quinn and Deriso 1999; R Core Team 2020). The estimator is based on equilibrium conditions and uses von Bertalanffy growth parameters (K and L_∞), length at first capture (L_c, i.e., the smallest size at which individuals are vulnerable to the fishery and sampling gear), and the mean length of individuals larger than L_c (Beverton and Holt 1956, 1957; Gedamke and Hoenig 2006). Total annual mortality (A) was estimated for Flathead Catfish using the following equation, $A = 1\text{-}e^{-Z}$ (Miranda and Bettoli 2007).

Results

Water temperatures during sampling ranged 27.5–33.9°C and were generally within the range recommended for effective catfish sampling (Bodine and Shoup 2010, Table 3). Field staff collected 383 Flathead Catfish, 61 Channel Catfish, 10 White Catfish, and 3 Blue Catfish from 55 sample sites. No other ictalurids were collected or observed while sampling. Flathead Catfish CPUE was 27.0 fish/h at sampling sites using LFE and 5.0 fish/h at sampling sites using HFE. Channel Catfish CPUE was 0.3 fish/h using LFE and 6.0 fish/h using HFE. White Catfish CPUE was 0.5 fish/h using LFE and 0.4 fish/h using HFE. Blue Catfish were only collected using LFE with a CPUE of 0.2 fish/h (Table 4).

Flathead Catfish ranged 128–1201 mm with a mean of 539 mm. Out of the total Flathead Catfish collected, 81% were quality-length with fewer at preferred- (49%), memorable- (33%), and trophy-length (9%) (Table 5, Figure 2). Mean W_r for Flathead Catfish was 89 (Table 5, Figure 3). Flathead Catfish total instantaneous mortality (Z) was 0.25, indicating a total annual mortality (A) of 22%.

Channel Catfish ranged 147–646 mm with a mean of 487 mm. Eighty-five percent of the Channel Catfish collected were quality-length and 18% were preferred-length. No memorable- or trophy-length Channel Catfish were collected (Table 5, Figure 4). Mean W_r for Channel Catfish was 92 (Table 5, Figure 5). Sixty Channel Catfish otoliths were collected with ages ranging 0–8 and a mean age of 3 (Figure 6). Channel Catfish were not collected in sufficient abundances to warrant mortality analysis.

White Catfish ranged 164–459 mm with a mean of 314 mm (Table 5). The three Blue Catfish ranged in size from 219 mm, 785 mm (age 4), and 829 mm (age 6; Table 5). White Catfish and Blue Catfish were not collected in sufficient abundances to warrant size distribution, relative weight, or mortality analyses.

Discussion

Abundance metrics, size-structure, body condition, and mortality analysis indicated robust populations of invasive Flathead Catfish in the Tar River. The high abundance and low mortality of Flathead Catfish populations indicated the population is growing and reproducing in a manner considered healthy for the species. Trophy-length flathead catfish were present in the survey, and body condition indicated that Flathead Catfish have adequate forage and density factors that are not an issue for this population. Furthermore, mortality of Flathead Catfish in the Tar River was low and similar to studies conducted in the Neuse River (Kwak et al. 2006; Rachels and Ricks 2014). A limitation of length-converted catch-curve analysis is the lack of a variance estimator to assess the precision of the mortality rate; future catfish surveys could collect age-length data to improve model precision. However, a more refined mortality estimate is not needed at this time due to the robustness of the Flathead Catfish populations.

Channel Catfish abundance was relatively low when compared to Flathead Catfish abundance. Channel Catfish size structure indicated the presence of quality- and preferred-length fish, while body condition indicated adequate access to forage. While low abundances may be due to predation by and competition with Flathead Catfish, it is possible that abundance was higher than what was observed and other methods may be needed to collect Channel Catfish more efficiently. Future surveys should evaluate other methods for targeting Channel Catfish so that sample sizes are large enough to better describe the population and ensure an accurate representation of their abundance.

White Catfish continue to be at low abundances in the Tar River. It is significant to note that as the abundance of Flathead Catfish increased, the abundance of White Catfish decreased during NCWRC Tar River catfish surveys (NCWRC, unpublished data). Future studies should continue to monitor the abundance of native bullheads, including the White Catfish.

In the Tar River, the robustness of the Flathead Catfish population in comparison to the native catfish population low abundances is a management concern. This disparity is likely due to predation by and competition with Flathead Catfish since the introduction, expansion, and establishment of the Flathead Catfish population in the Tar River (Rachels and Ricks 2018; NCWRC, unpublished data). Borawa (1983) found that White Catfish comprised 83.5% of the total weight of stomach contents from Flathead Catfish collected in the Northeast Cape Fear River. A survey by Rachels and Ricks (2018) suggested that the Tar River catfish assemblage is dominated by Flathead Catfish. Our 2020 survey results continue to support these previous findings in the Tar River. Expansion of Blue Catfish abundance in the basin should also be monitored, as this non-native catfish also has the potential to impact native ictalurids.

Management Recommendations

1. Maintain current harvest regulations and status designations for all native, non-native, and invasive catfish species in the Tar River according to the NCWRC Catfish Management Plan.
2. Promote angler harvest of Flathead Catfish and Blue Catfish in the Tar River.
3. Consider additional sampling methodologies and techniques to better describe catfish species populations in the Tar River.
4. Conduct a creel survey to document changes in angling patterns and harvest practices in the Tar River since the last creel survey conducted from 2004 to 2005.
5. Collaborate with the North Carolina Department of Health and Human Services and North Carolina Department of Natural Resources to identify any consumption advisories by size for Flathead Catfish in the Tar River.
6. Monitor the Tar River catfish populations every 3 to 5 years or as needed to document changes in population characteristics.

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TABLE 1. Low frequency electrofishing sample site information for the 2020 Tar River Catfish Survey. Note: All discharge data provided below were recorded on the USGS Tarboro, NC (02083500) and Greenville, NC (02084000) Tar River gauges located near the Dunbar Bridge and Greenville Town Commons boating access areas, respectively.

Sample date	Site name	Latitude	Longitude	Boating access area	Discharge (CFS)
July 13	TAR115	35.9399000	-77.6566000	Dunbar Bridge	512
July 13	TAR113	35.9479000	-77.6427000	Dunbar Bridge	512
July 20	TAR50	35.6871986	-77.4775009	Falkland	471
July 20	TAR48	35.6749001	-77.4695969	Falkland	471
July 21	TAR40	35.6369019	-77.4075012	Town Commons	437
July 21	TAR39	35.6357002	-77.4017029	Town Commons	437
July 21	TAR36	35.6188011	-77.3920975	Town Commons	437
July 22	TAR33	35.6160011	-77.3601990	Town Commons	446
July 22	TAR30	35.6087990	-77.3308029	Town Commons	446
July 22	TAR28	35.5993996	-77.3131027	Town Commons	446
July 22	TAR25	35.5898000	-77.2884000	Town Commons	446
July 22	TAR22	35.5982000	-77.2631000	Town Commons	446
July 23	TAR20	35.6075000	-77.2446000	Port Terminal	530
July 23	TAR17	35.6055000	-77.2127000	Port Terminal	530
July 23	TAR14	35.5864000	-77.1916000	Port Terminal	530
July 23	TAR12	35.5751991	-77.1781998	Port Terminal	530
July 27	TAR9	35.5689000	-77.1464000	Masons Landing	623
July 27	TAR7	35.5644000	-77.1266000	Masons Landing	623
July 27	TAR5	35.5591000	-77.1071000	Masons Landing	623
July 27	TAR3	35.5512009	-77.0910034	Masons Landing	623
August 3	TAR2	35.5485992	-77.0818024	Masons Landing	622
August 3	TAR1	35.5457993	-77.0721970	Masons Landing	622
August 3	PAM1	35.5377300	-77.0526600	Masons Landing	622
August 5	TAR100	35.9463997	-77.5794983	Bell Bridge	1,430
August 5	TAR97	35.9356000	-77.5630000	Bell Bridge	1,430
August 5	TAR94	35.9280000	-77.5449000	Bell Bridge	1,430
August 6	TAR84	35.9157000	-77.5105000	Bell Bridge	2,950
August 6	TAR80	35.9005000	-77.5045000	Bell Bridge	2,950
August 6	TAR75	35.8768000	-77.5361000	Bell Bridge	2,950
August 6	TAR70	35.8347000	-77.5457000	Bell Bridge	2,950
August 6	TAR67	35.8085000	-77.5473000	Bell Bridge	2,950
August 6	TAR65	35.7908000	-77.5504000	Bell Bridge	2,950

TABLE 2. High frequency electrofishing sample site information for the 2020 Tar River Catfish Survey. Note: All discharge data provided below were recorded on the USGS Tarboro, NC (02083500) and Greenville, NC (02084000) Tar River gauges located near the Dunbar Bridge and Greenville Town Commons Boating Access Areas, respectively.

Sample date	Site name	Latitude	Longitude	Boating access area	Discharge (CFS)
July 13	TAR114	35.9422000	-77.6473000	Dunbar Bridge	512
July 13	TAR112	35.9437000	-77.6395000	Dunbar Bridge	512
July 20	TAR52	35.6999000	-77.4913000	Falkland	471
July 20	TAR49	35.6792984	-77.4786987	Falkland	471
July 20	TAR46	35.6593018	-77.4602966	Falkland	471
July 21	TAR41	35.6404000	-77.4169000	Town Commons	437
July 21	TAR38	35.6310997	-77.3955994	Town Commons	437
July 21	TAR37	35.6257019	-77.3963013	Town Commons	437
July 22	TAR32	35.6152000	-77.3492966	Town Commons	446
July 22	TAR29	35.6041985	-77.3221970	Town Commons	446
July 22	TAR27	35.5984000	-77.3037000	Town Commons	446
July 22	TAR24	35.5937000	-77.2808000	Town Commons	446
July 23	TAR19	35.6092000	-77.2339000	Port Terminal	530
July 23	TAR16	35.5997000	-77.2043000	Port Terminal	530
July 23	TAR13	35.5814018	-77.1834030	Port Terminal	530
July 27	TAR8	35.5664000	-77.1362000	Masons Landing	623
July 27	TAR6	35.5601000	-77.1176000	Masons Landing	623
July 27	TAR4	35.5522000	-77.1016000	Masons Landing	623
August 5	TAR99	35.9459000	-77.5708000	Bell Bridge	1,430
August 5	TAR96	35.9303000	-77.5607000	Bell Bridge	1,430
August 6	TAR83	35.9135000	-77.5053000	Bell Bridge	2,950
August 6	TAR79	35.8973000	-77.5134000	Bell Bridge	2,950
August 6	TAR73	35.8592000	-77.5336000	Bell Bridge	2,950

TABLE 3. Water quality measurements collected at electrofishing sample sites from the 2020 Tar River Catfish Survey.

Parameter	Mean	SE	Minimum	Maximum
Water Temperature (°C)	30.4	0.2	27.5	33.9
Dissolved Oxygen (mg/L)	6.3	0.1	5.5	9.3
Conductivity (µS/cm)	136.4	7.6	96.9	426.8
Salinity ($^0/_{00}$)	0.2	0.03	0.0	0.8

TABLE 4. Species composition and relative abundance by electrofishing setting from the 2020 Tar River Catfish Survey.

			CPUE (fish/h)	
Species	Number collected	Percent collected (%)	15 PPS	120 PPS
Flathead Catfish	383	84	27	5
Channel Catfish	61	13	0.3	6
White Catfish	10	2	0.5	0.4
Blue Catfish	3	1	0.2	
Total	457	100		

TABLE 5. Minimum total length (Min.), maximum total length (Max.), mean total length, size indices, and condition of select species from electrofishing during the 2020 Tar River Catfish Survey. Note: All lengths represent total length (TL) in millimeters (mm).

Species	Min. TL (mm)	Max. TL (mm)	Mean TL (mm)	PSD-Q	PSD-P	PSD-M	PSD-T	Mean Wr
Flathead Catfish	128	1201	539	81	49	33	9	89
Channel Catfish	147	646	487	85	18			92
White Catfish	164	459	314					
Blue Catfish	219	829	611					

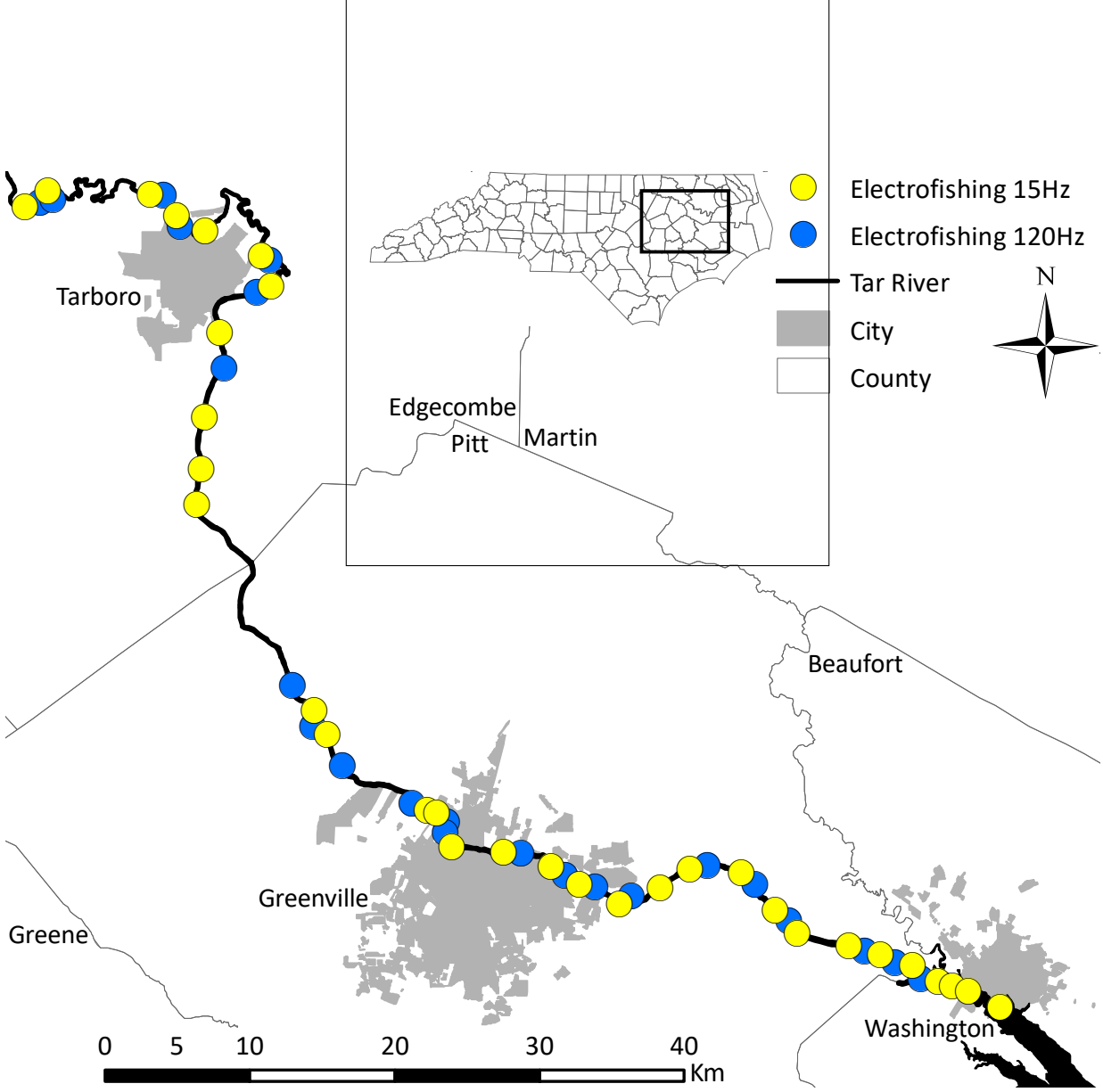

FIGURE 1. Map of the 2020 Tar River Catfish Survey sampling sites on the Tar River in Edgecombe, Pitt, and Beaufort counties, North Carolina.

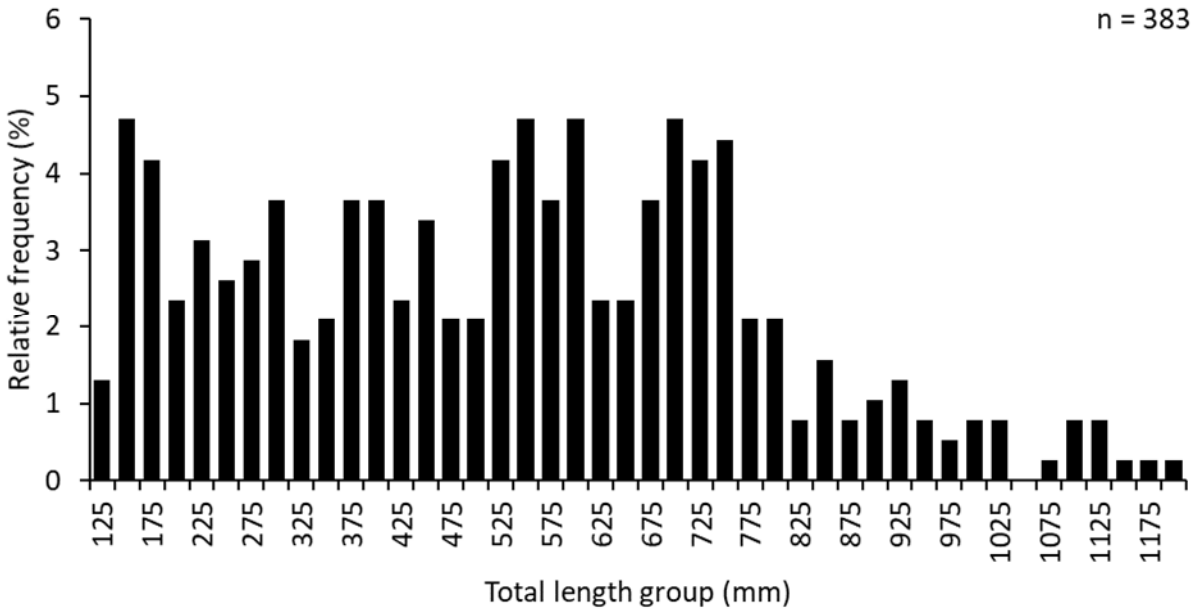

FIGURE 2. Length frequency distribution for Flathead Catfish collected via electrofishing during the 2020 Tar River Catfish Survey.

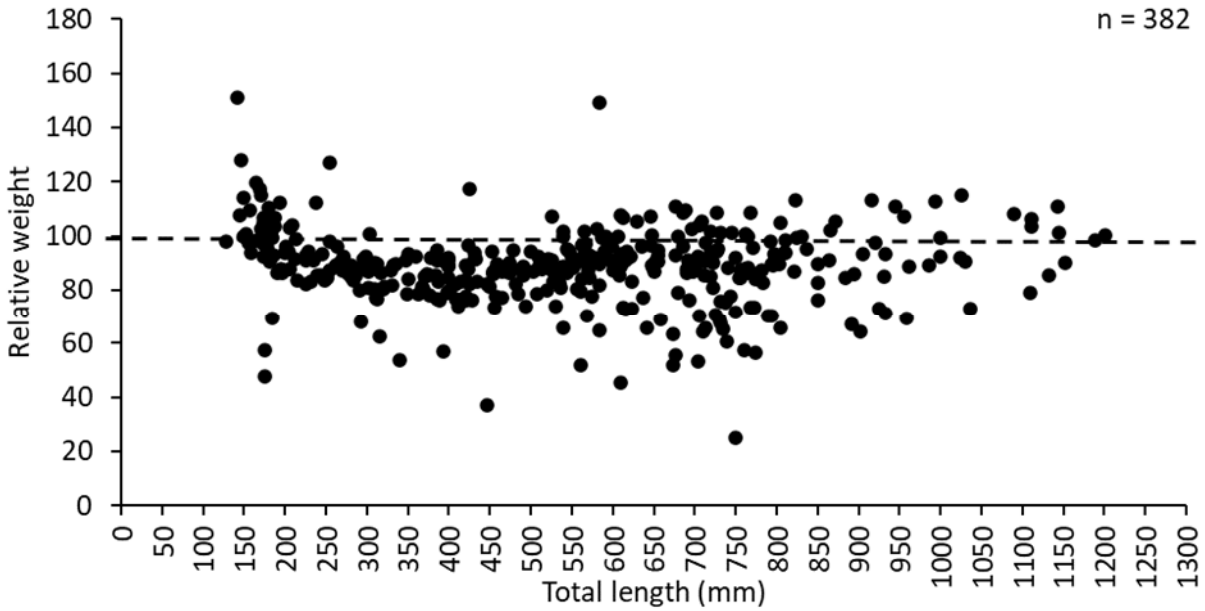

FIGURE 3. Relationship between total length and relative weight of Flathead Catfish collected via electrofishing during the 2020 Tar River Catfish Survey. The dashed line represents the 75th percentile of relative weight for Flathead Catfish across their geographical distribution.

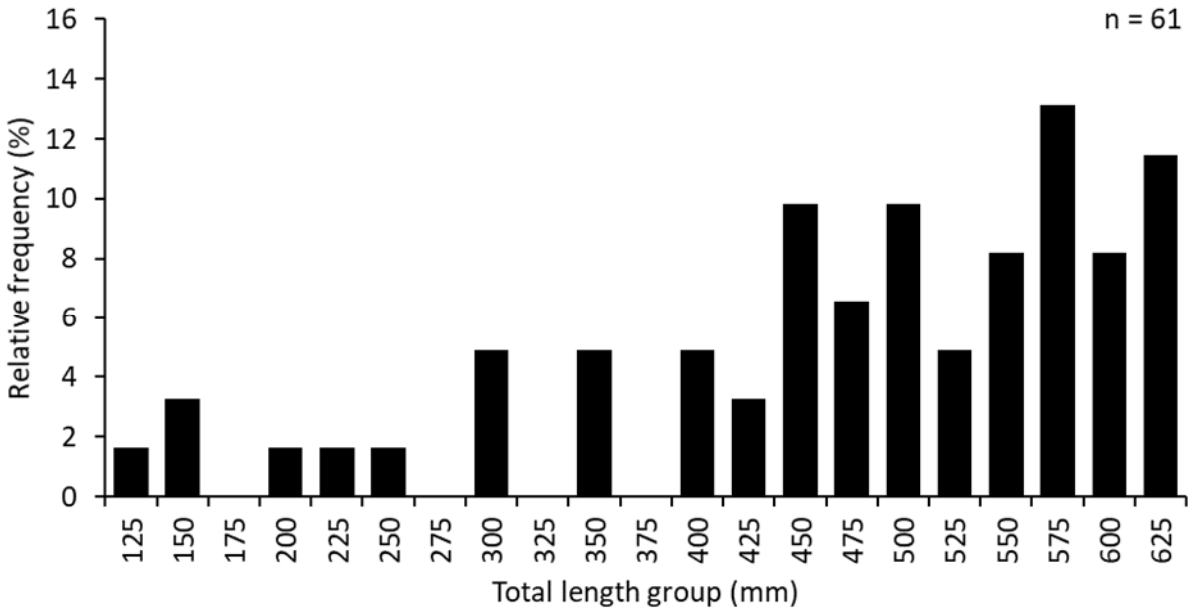

FIGURE 4. Length frequency distribution for Channel Catfish collected via electrofishing during the 2020 Tar River Catfish Survey.

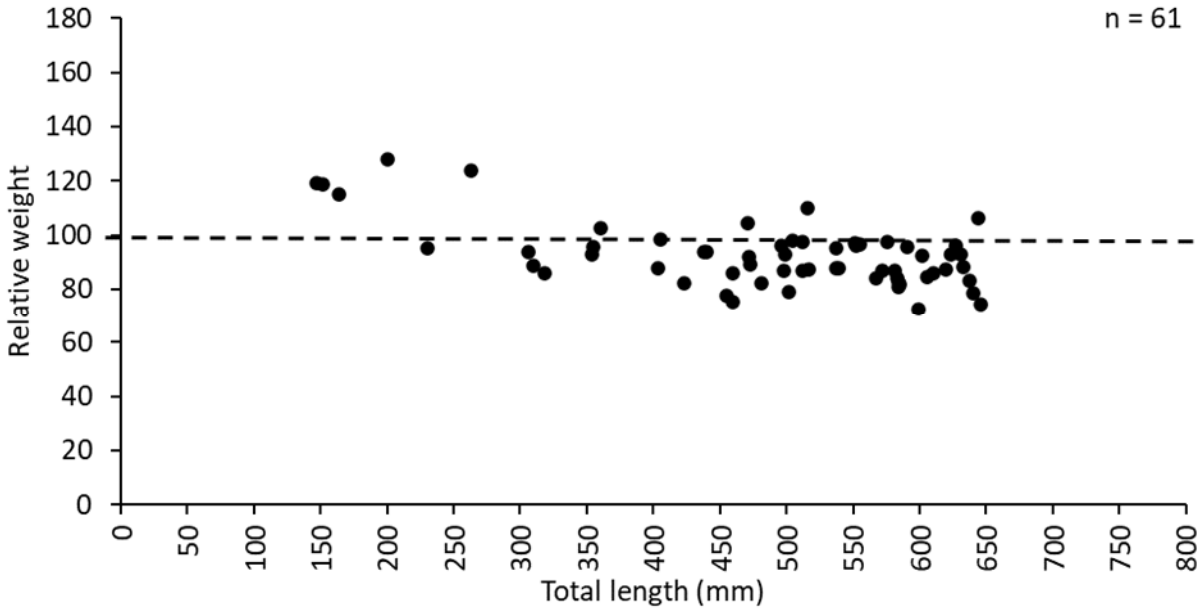

FIGURE 5. Relationship between total length and relative weight of Channel Catfish collected via electrofishing during the 2020 Tar River Catfish Survey. The dashed line represents the 75th percentile of relative weight for Channel Catfish across their geographical distribution.

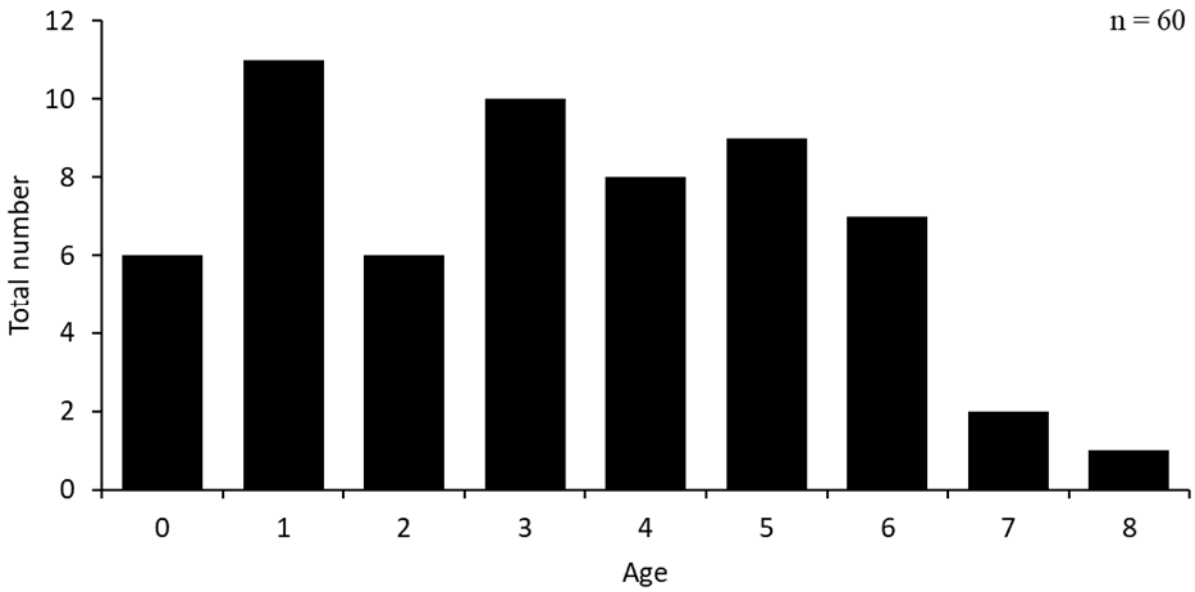

FIGURE 6. Age frequency for Channel Catfish collected via electrofishing during the 2020 Tar River Catfish Survey.