Fisheries resources of the Lumber River

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Abstract. In the summer of 1960 and 1961, the N.C. Wildlife Resources Commission (NCWRC) conducted a baseline survey of fish populations in the Lumber River Basin. Subsequent surveys were largely focused on sport fish species or Species of Greatest Conservation Need. A systematic boat-mounted electrofishing survey was conducted in the Lumber River in 2015 and 2016 to elucidate the effect of hand-crank electrofishing on introduced catfish populations. The purpose of this report is to summarize data collected in that survey and provide comparisons to previous surveys. Overall, 2,055 fish representing 47 species were collected, including 19 Inland Game Fish, 8 nonnative species and 5 Species of Greatest Conservation Need. Fifteen species were collected in this survey that were not observed in 1960–1961. Redbreast Sunfish, Bluegill, Chain Pickerel, and Largemouth Bass were the most abundant Inland Game Fish, while Bowfin, Longnose Gar, Flathead Catfish, and Spotted Sucker were the most abundant nongame fish. An age-8 Redbreast Sunfish collected in this survey is the oldest recorded in North Carolina, while an age-17 Largemouth Bass is tied for fourth oldest collected by NCWRC. Overall, the Lumber River offers unique angling opportunities. However, introduced species and emerging habitat issues require monitoring to mitigate potential negative impacts to the Lumber River's fisheries resources.

The earliest ichthyological survey of the Lumber River was conducted in 1913 by B. W. Evermann in what is now called Drowning Creek, just upstream from its confluence with Buffalo Creek and the currently accepted origin of the Lumber River (Evermann 1916). However, the river's fisheries remained largely undescribed until the North Carolina Wildlife Resources Commission (NCWRC) surveyed the Lumber River in the summer of 1960 and 1961 as part of a systematic inventory of ichthyofauna in the state's river basins (Louder 1962). Surveys became more frequent by the 1990s due to the development of boat electrofishing, although published reports typically excluded species that were not centrarchids or ictalurids (e.g., Ashley and Rachels 1998; Rachels and Ashley 2002; *but* Ashley and Rachels 1999).

In 2015 and 2016, NCWRC conducted a survey to assess the effects of hand-crank electrofishing on vital rates and abundance of fish populations in Southeastern North Carolina. The primary goal, assessing impacts of hand-crank electrofishing on nonnative catfish populations, was addressed by Fisk et al. (2019). The following report is a general summary of the fisheries resources in the Lumber River in 2015–2016. Comparisons are made to the catch composition reported by Louder (1962). Age structure, growth, and mortality are contrasted with other rivers assessed during the 2015–2016 hand-crank electrofishing project.

Methods

Study site. The Lumber River is a free-flowing coastal plain stream (Strahler Order = 5) arising from the confluence of Drowning Creek and Buffalo Creek near Wagram, NC (Figure 1). It flows approximately 214 km to its confluence with the Little Pee Dee River near Nichols, SC. The Lumber River watershed (U.S. Geological Survey hydrologic unit 03040203) in North Carolina drains 4,224 km^2 (an additional 316 km^2 is in South Carolina) and is 33% agriculture, 25% wetland, 21% forested, 13% grassland/shrub, 7% developed, and 1% open water (USDA 2021). As of 2021, there are 9 major and 18 minor NPDES permitted discharges (NCDWR 2021). Additionally, there are 19 public municipal stormwater systems rated in fair or poor condition that utilize no best management practices (NC One Map 2021). The Lumber River is classified as High Quality Waters from its source to U.S. Highway 301 near Lumberton, NC (NCDENR 2007). In 1998, 130 km were designated by the U.S. Department of the Interior as a state-managed National Wild and Scenic River (National Park Service 1998).

A stratified-random survey design was employed for fish collections in June 2015 and June 2016. Two strata were of interest to the primary goal of the project: a stratum where hand-crank electrofishing is allowed [Columbus County; river kilometer (RKM) 28–RKM 67] and a stratum where hand-crank electrofishing is prohibited (Robeson, Hoke, and Scotland counties; RKM 78–RKM 214). A 10-km buffer was maintained between the two strata to minimize the probability of sampling fish that utilize both strata. Five 0.5-km sites were randomly selected in each stratum (10 sites total) to target all fish species. Ten additional 1-km sites were randomly selected in each stratum (20 sites total) to target catfish. For the purpose of this report, strata sampling data were aggregated and were given no further consideration.

Field collection. In the 10 sites targeting all fish species, boat-mounted electrofishing (Smith-Root 7.5 GPP; 120 Hz; 4,000–8,000 W) was utilized along each shoreline (1-km sample). All fish were collected as encountered, and voucher specimens were preserved in buffered formalin if identification could not be ascertained in the field. Low-frequency boat-mounted electrofishing (Smith-Root 7.5 GPP; 15 Hz; 1,800–2,500 W) was used in the 20 sites targeting catfish. A chase boat was employed to increase catch rates. Boats proceeded downstream through the 1-km sample site at 4–8 kph, and all ictalurids were collected as encountered.

For both sampling methods, all collected fish were measured for total length (TL; mm) and weight (g). Otoliths were removed from up to 10 fish per 2-cm size-class for the following species: Flathead Catfish *Pylodictis olivaris*, Blue Catfish *Ictalurus furcatus*, Channel Catfish *I. punctatus*, Bluegill *Lepomis macrochirus*, Largemouth Bass *Micropterus salmoides*, Redbreast Sunfish *L. auritus*, and Redear Sunfish *L. microlophus*. Fish in young-of-year size-classes were assumed age 0 following Carlander (1969, 1977). Catfish otoliths were prepared according to Nash and Irwin (1999) and Buckmeier et al. (2002) and read by two independent readers. Centrarchid otoliths were prepared following Long and Grabowski (2017) and were also read by two independent readers. Age disagreements were resolved, or individuals were removed from the age dataset following a concert read. Multinomial age-length keys (Ogle 2015) were constructed, and individual ages were assigned following the method of Isermann and Knight (2005).

Data analyses. Catch of each species was compared to Louder (1962). Relative abundance was indexed as catch-per-unit-effort (fish/h). Density plots were used to summarize size structure for species with five or more collected individuals. Relative frequency plots were used to examine age-class composition.

Growth was modeled using a Bayesian methodology and the von Bertalanffy growth function (VBGF; Beverton and Holt 1957; Doll and Jacquemin 2019). The von Bertalanffy growth function is expressed as

$$L_T = L_\infty\left[1 - e^{-K(T-t_0)}\right],$$

Where L is length, L_∞ is the mean length of the oldest age class (asymptotic length), K describes how quickly mean length at age approaches L_∞, t_0 represents the age when mean fish length is zero, and T denotes age. Informative priors for L_∞ were derived using the NCWRC BIODE database. Specifically, each species had a prior for L_∞ that was Gaussian distributed with a mean and standard deviation calculated from the maximum total lengths of each BIODE project with total length data collected between 2000 and 2014. Projects that did not have sufficient information (i.e., catch of sufficiently large individuals for a given species) were excluded from developing the prior. Priors for the other model estimated parameters (K and t_0) were weakly informative and constant across species [$K \sim$ Cauchy(0.25, 0.25) with a lower bound of zero; $t_0 \sim$ Cauchy(0, 1)]. Growth models were implemented using Stan (Stan Development Team 2019) as implemented through R package "brms". All growth models used 4 concurrent Markov chain Monte Carlo (MCMC) chains, each with 4,000 total iterations, no thinning, and a 2,000 iteration burn-in period. Models were deemed to have reached approximate convergence if visual examination of trace plots indicated the MCMC chains were stationary and mixed, and the potential scale reduction factor ($\hat{R}$) of each estimated parameter was less than 1.1 (Gelman and Shirley 2011; Doll and Jacquemin 2019). The fit of each model was assessed by conducting a posterior predictive check (Doll and Jacquemin 2019).

Poisson log-linear models were used to estimate instantaneous total mortality (*Z*; Millar 2015). Poisson regression is the most robust catch-curve method to assumption violations, which include: recruitment is constant through time, mortality is constant through time and across ages, all fish are equally vulnerable to the sampling gear, and the age composition is estimated without error (Nelson 2019). Age at recruitment to the catch-curve was considered the modal age plus one year (*i.e.*, Peak +1; Smith et al. 2012; Nelson 2019). All data analyses were conducted using R 4.0.

Results

Catch. A total of 2,055 individuals representing 47 species were collected (Table 1). American Eel *Anguilla rostrata*, Bluegill, Bowfin *Amia calva*, Dollar Sunfish *L. marginatus*, Largemouth Bass, Longnose Gar *Lepisosteus osseus*, Redbreast Sunfish, and Redfin Pickerel *Esox americanus* were all collected in 100% of the sample sites in which they were targeted. Redbreast Sunfish, Bluegill, Chain Pickerel *E. niger*, and Largemouth Bass were the most abundant Inland Game Fish, while Bowfin, Longnose Gar, Flathead Catfish, and Spotted Sucker *Minytrema melanops* were the most abundant nongame fish. In general, the relative abundance of the four most abundant Inland Game Fish was greater in upstream sampling sites compared to downstream sampling sites (Figure 2). For the four most abundant nongame fish, Bowfin and Longnose Gar were most abundant in downstream sample sites, Spotted Sucker were most abundant in the upstream sample sites, and Flathead Catfish were most abundant near the South Carolina state line and near the city of Lumberton (Figure 3).

High frequency electrofishing sites with the greatest species diversity were RKM 35, RKM 202, and RKM 203 with 26 species collected (Table 2). River kilometer 203 also had the greatest catfish diversity with 4 species collected using low frequency electrofishing (Table 3). With the exception of RKM 202, Flathead Catfish were captured in all low frequency electrofishing sites (Table 3).

Fifteen species were collected that were not present in the 1960–1961 survey by Louder (1962). Among those were seven nonnative species, four of which were likely introduced after the 1960–1961 survey [Blue Catfish, Flathead Catfish, Grass Carp *Ctenopharyngodon idella*, and Spotted Bass *Micropterus* sp. (see page 6 for discussion on "Spotted Bass")]. Banded Pygmy Sunfish *Elassoma zonatum*, Banded Sunfish *Enneacanthus obesus*, Bluespotted Sunfish *E. gloriosus*, Broadtail Madtom *Noturus* sp., Eastern Mudminnow *Umbra pygmaea*, Lake Chubsucker *Erimyzon sucetta*, Lined Topminnow *Fundulus lineolatus*, Sawcheek Darter *Etheostoma serrifer*, Swamp Darter *E. fusiforme*, and Yellow Bullhead *Ameiurus natalis* were present in the 1960–1961 survey but were not observed in 2015–2016 (Table 1). Most of these species are difficult to sample using boat-mounted electrofishing due to their small size, physiology, or habitat preference. Finally, three of the five Species of Greatest Conservation Need (SGCN) observed in this survey exhibited a decline in site occupancy compared to Louder (1962); only Thinlip Chub *Cyprinella* sp. and Snail Bullhead *Ameiurus brunneus* were collected in more sampling sites than in Louder (1962).

Size structure. Seventeen Inland Game Fish and 18 nongame species had at least 5 collected individuals and were described using density plots. Chain Pickerel were the largest Inland Game Fish, followed by Largemouth Bass, Spotted Bass, and Brown Bullhead *A. nebulosus* (Figure 4). Redear Sunfish were the largest lepomid, followed by Redbreast Sunfish and Bluegill (Figure 4). Flathead Catfish were the largest nongame fish, followed by Longnose

Gar, Common Carp *Cyprinus carpio*, and Bowfin (Figure 5). The largest Flathead Catfish in this survey (1,128 mm) surpasses the previously observed maximum size in the Lumber River (965 mm) and is similar to the maximum observed size in other introduced populations (Kwak et al. 2006).

Age structure. Bluegill ranged from age 0 to age 5, with age-0 to age-1 fish comprising 62% of the population (Figure 6). Channel Catfish ranged from age 2 to age 13, but 93% of the population was age 2–4 (Figure 6). Flathead Catfish ranged from age 1 to age 13 with 90% between age 1 and age 4 (Figure 6). Largemouth Bass displayed an especially broad age range with 13 age-classes present and a maximum age of 17, although 58% were age 2 or less (Figure 6). Redbreast Sunfish were the oldest lepomid, with a maximum age of 8 (Figure 6). Redear Sunfish ranged from age 0 to age 6, with 92% between age 0 and age 3 (Figure 6).

Flathead Catfish age structure was similar to that reported by Kwak et al. (2006), who reported a maximum age of 12 in the Lumber River. Lumber River Flathead Catfish exhibit the youngest age-structure among southeastern NC rivers (Rachels and Fisk 2021a, 2021b, 2021c). The age-17 Largemouth Bass is among the oldest observed in North Carolina, the oldest being an age-20 fish from Lake Townsend (Baumann and Oakley 2011). Bluegill maximum age was typical among southeastern NC populations (Rachels and Fisk 2021a, 2021b, 2021c). The Channel Catfish maximum age was greatest among southeastern NC populations (Rachels and Fisk 2021a, 2021b, 2021c). The age-8 Redbreast Sunfish in this survey is the oldest reported in North Carolina (previous max age = 6; Richardson and Ratledge 1961; Davis 1971; Ashley and Rachels 1998). Redear Sunfish age structure was similar to the Waccamaw River population (Rachels and Fisk 2021c) with a maximum age of 6.

Growth. Approximate convergence was achieved for all von Bertalanffy growth models, and graphical posterior predictive checks suggested each model adequately replicated the observed data. The Bluegill VBGF appeared to be negatively biased at older ages, although all age-5 observations fell withing the 90% credible interval (CI) for the posterior predictive distribution (Figure 7). The VBGF for Channel Catfish exhibited the greatest uncertainty among the fitted models (Figure 7), with the estimated 90% CI for K ranging from 0.14 to 0.31 (Table 4). Additionally, the degree of overlap between the prior and joint posterior distributions for L_∞ suggests the prior was highly influential (Figure 8). The Flathead Catfish VBGF model fit was precise, although the estimated L_∞ was over 100 mm greater than the largest observed individual (Table 4, Figure 7). Nonetheless, the estimated Flathead Catfish VBGF model parameters were very similar to those reported by Kwak et al. (2006) for the Lumber River in 2003 and similar to populations in the Black and Waccamaw rivers (Rachels and Fisk 2021b, 2021c). Model uncertainty for the Largemouth Bass VBGF increased after age 8 due to the small observed sample size in the age-8 through age-17 cohorts (Figure 7), but growth was comparable to other southeastern NC populations (Rachels and Fisk 2021a, 2021b, 2021c). Both Redbreast Sunfish and Redear Sunfish VBGF models appeared to exhibit low bias throughout the ages observed (Figure 7) and exhibited the fastest growth compared to populations in the Black, Cape Fear, and Waccamaw rivers (Rachels and Fisk 2021a, 2021b, 2021c).

Mortality. Bluegill experienced the greatest mortality of the six species (Table 5) and was greater than Bluegill populations in other southeastern NC rivers (Rachels and Fisk 2021a, 2021b, 2021c). Channel Catfish mortality was estimated with reasonable precision (Table 5); however, the estimate should be viewed with caution given the small sample size and prevalence of missing age-classes (Figure 6). Flathead Catfish, Largemouth Bass, and Redbreast Sunfish mortality estimates were relatively precise (Table 5). Flathead Catfish mortality was slightly greater than a 2003 estimate (Z = 0.21) reported by Kwak et al. (2006). Largemouth Bass and Redbreast Sunfish mortality rates were the lowest for their species among southeastern NC populations (Rachels and Fisk 2021a, 2021b, 2021c). Very few Redear Sunfish were collected that were greater than the modal age, resulting in a very imprecise mortality estimate (Table 5).

Discussion

The Lumber River supports the most diverse fish community among southeastern NC rivers (Rachels and Fisk 2021a, 2021b, 2021c) and offers unique angling opportunities. The abundance, size, and age-structure of Redbreast Sunfish is likely the best in North Carolina. The mortality rate and broad age structure of Largemouth Bass suggest the fishery is lightly exploited. These fisheries are readily accessible to small boat and bank anglers at access areas maintained by NCWRC and Lumber River State Park.

Comparisons are made between the sample composition in this survey and the 1960–1961 survey by Louder (1962). These comparisons are somewhat tenuous given the different sampling gears utilized by the surveys. Nonetheless, the current survey suggests an overall decline in SGCN since the Louder (1962) survey. Additional surveys using a broad range of sampling gears, coupled with alternative analytical techniques (e.g., occupancy modeling), may aid in elucidating the current status of SGCN in the Lumber River.

Introduced species are among the most visible threats to the Lumber River's fisheries resources. Flathead Catfish have well-documented negative impacts on native sunfish and catfish (NCWRC 2019). Indeed, in this survey native catfish species were only observed in the most upstream sample sites where Flathead Catfish were not collected. Another nonnative species, referred to as "Spotted Bass" in this report, is of unknown origin but was first stocked in North Carolina in the Cape Fear River in 1978 from Coosa River, AL, source broodfish (Marshall Ray; personal communication; Nichols and Buff 1984) which precludes *Micropterus punctulatus*. It is unknown if the Spotted Bass of the Lumber River originated from angler introductions in North Carolina or South Carolina. Nonetheless, the introduction of congeners has caused significant impacts to Largemouth Bass in other waterbodies in North Carolina (e.g., Dorsey and Abney 2016). Although the Spotted Bass population appears to be limited in the Lumber River, additional study is needed to elucidate the current status of *Micropterus* populations and the impacts of introduced black bass species.

Habitat and water quality degradation also negatively impact fish populations in the Lumber River. Timber harvest and land-use changes, in areas adjacent to both the river and its tributaries, can increase sedimentation and negatively impact the temperature, streamflow, and dissolved oxygen regimes in the river (Filipek 1993). Similarly, clearing and snagging activity in the main stem Lumber River is occasionally initiated for flood-control purposes but has no long-term utility, increases sedimentation, and greatly diminishes fish habitat (Cobb and Kaufman 1993). Removal of large woody debris (LWD) in the river through clearing and snagging is especially harmful to Redbreast Sunfish, which prefer LWD habitat for spawning (Davis 1971; Bass and Hitt 1974; Sandow et al. 1974).

Finally, climate models project an increase in the frequency of extreme precipitation events in North Carolina, as well as more intense hurricanes (Kunkel et al. 2020), thereby increasing the likelihood of high streamflow events. These events can have significant negative impacts on water quality (Mallin and Corbett 2006; NCDEQ 2019) and lead to widespread fish kills. Potential infrastructure adaptations intended to reduce the impacts of high streamflow on human populations adjacent to the Lumber River—adaptations including but not limited to channelization, watershed storage, and flow diversions—would likely negatively impact many native fish species (Bryan and Rutherford 1993). Continued monitoring, and NCWRC engagement in activities proposed to reduce the flood risk of human communities, are necessary to maintain the integrity of fisheries resources in the Lumber River. Additionally, fisheries hurricane response plans should be formalized and broadened to encompass goals that promote long-term resilience and management strategies that proactively reduce the risk of chronic stressors and acute fish kill events.

Management Recommendations

1. Maintain current size and creel regulations for all Inland Game Fish.
2. Reduce populations of Flathead Catfish and "Spotted Bass" by reducing barriers to harvest and investigating novel control techniques.
3. Investigate occupancy of native catfish.
4. Within 2 years, conduct biological and genetic surveys to investigate the impacts of "Spotted Bass."
5. Within 5 years, conduct a creel survey to assess current harvest rates and angling practices.
6. Within 10 years, conduct basin-wide survey of Lumber River fish communities.
7. Identify, plan, fund, and support projects throughout the river basin that improve fish habitat and water quality.

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TABLE 1. Species collected in hand-crank electrofishing survey (2015–2016) and Louder (1962; 1960–1961). **Bold** denotes Inland Game Fish, *italics* denote Species of Greatest Conservation Need, and (◊) denotes nonnative species.

Common name	Scientific name	Catch 1960–1961	Catch 2015–2016	Sites with catch 1960–1961 [a]	Sites with catch 2015–2016 [b]
American Eel	*Anguilla rostrata*	42	72	89%	100%
Banded Pygmy Sunfish	*Elassoma zonatum*	15	0	67%	0%
Banded Sunfish	*Enneacanthus obesus*	17	0	33%	0%
Black Crappie	*Pomoxis nigromaculatus*	99	8	33%	30%
Blackbanded Sunfish	*Enneacanthus chaetodon*	4	2	44%	10%
◊ Blue Catfish	*Ictalurus furcatus*	0	1	0%	3%
Bluegill	*Lepomis macrochirus*	170	173	89%	100%
Bluespotted Sunfish	*Enneacanthus gloriosus*	51	0	78%	0%
Bowfin	*Amia calva*	4	233	11%	100%
Broadtail Madtom	*Noturus sp.*	2	0	11%	0%
Brown Bullhead	*Ameiurus nebulosus*	0	9	0%	3%
Chain Pickerel	*Esox niger*	47	98	89%	50%
◊ Channel Catfish	*Ictalurus punctatus*	0	34	0%	40%
Coastal Shiner	*Notropis petersoni*	44	83	56%	80%
◊ Common Carp	*Cyprinus carpio*	0	6	0%	30%
Creek Chubsucker	*Erimyzon oblongus*	130	6	67%	30%
Dollar Sunfish	*Lepomis marginatus*	3	62	22%	100%
Dusky Shiner	*Notropis cummingsae*	150	16	44%	50%
Eastern Mosquitofish	*Gambusia holbrooki*	45	1	67%	10%
Eastern Mudminnow	*Umbra pygmaea*	1	0	11%	0%
Flat Bullhead	*Ameiurus platycephalus*	9	31	22%	10%
◊ Flathead Catfish	*Pylodictis olivaris*	0	154	0%	87%
Flier	*Centrarchus macropterus*	5	7	11%	40%
Gizzard Shad	*Dorosoma cepedianum*	0	3	0%	20%
Golden Shiner	*Notemigonus crysoleucas*	157	10	100%	40%
◊ Grass Carp	*Ctenopharyngodon idella*	0	1	0%	10%
Ironcolor Shiner	*Notropis chalybaeus*	211	2	89%	20%

TABLE 1. Continued…

Common name	Scientific name	Catch 1960–1961	Catch 2015–2016	Sites with catch 1960–1961 [a]	Sites with catch 2015–2016 [b]
Lake Chubsucker	*Erimyzon sucetta*	16	0	22%	0%
Largemouth Bass	*Micropterus salmoides*	47	96	100%	100%
Lined Topminnow	*Fundulus lineolatus*	6	0	44%	0%
Longnose Gar	*Lepisosteus osseus*	4	182	33%	100%
Margined Madtom	*Noturus insignis*	30	18	44%	20%
Mud Sunfish	*Acantharchus pomotis*	1	1	11%	10%
Piedmont Darter	*Percina crassa*	0	1	0%	10%
Pirate Perch	*Aphredoderus sayanus*	144	14	100%	40%
Pumpkinseed	*Lepomis gibbosus*	69	11	78%	50%
Redbreast Sunfish	*Lepomis auritus*	51	222	67%	100%
◊ Redear Sunfish	*Lepomis microlophus*	0	93	0%	90%
Redfin Pickerel	*Esox americanus*	21	79	67%	100%
Satinfin Shiner	*Cyprinella analostana*	0	1	0%	10%
Sawcheek Darter	*Etheostoma serrifer*	26	0	67%	0%
Shorthead Redhorse	*Moxostoma macrolepidotum*	0	1	0%	10%
Snail Bullhead	*Ameiurus brunneus*	0	9	0%	7%
Southern Brook Silverside	*Labidesthes vanhyningi*	0	28	0%	90%
Spottail Shiner	*Notropis hudsonius*	1	8	11%	50%
◊ Spotted Bass [c]	*Micropterus* sp.	0	25	0%	60%
Spotted Sucker	*Minytrema melanops*	75	126	78%	90%
Spotted Sunfish	*Lepomis punctatus*	0	62	0%	90%
Swamp Darter	*Etheostoma fusiforme*	23	0	33%	0%
Swampfish	*Chologaster cornuta*	1	5	11%	40%
Tadpole Madtom	*Noturus gyrinus*	20	1	67%	3%
Taillight Shiner	*Notropis maculatus*	66	7	22%	20%
Tessellated Darter	*Etheostoma olmstedi*	22	3	67%	20%
Thinlip Chub	*Cyprinella sp.*	2	11	11%	30%
Warmouth	*Lepomis gulosus*	53	20	89%	60%
Yellow Bullhead	*Ameiurus natalis*	19	0	67%	0%
Yellow Perch	*Perca flavescens*	8	19	56%	50%

[a] Sites 14I-1, 14J-5, 14J-6, 15I-5, 15I-12, 15J-2, 16H-3, 16H-7, and 16I-8 in Louder (1962) as amended by Starnes and Hogue (2011).

[b] Percentages calculated with catfish targeted in all sites (*n* = 30); other species targeted in high-frequency sites only (*n* = 10).

[c] This species has historically been considered *M. punctulatus* but awaits genetic species identification.

TABLE 2. Aggregated catch (2015 and 2016) by high frequency (120 PPS) electrofishing site. The final row gives the number of species captured within each site.

	River kilometer									
Species	28	31	35	45	51	97	101	150	202	203
American Eel	2	7	6	8	12	2	10	7	10	8
Black Crappie	0	0	4	2	2	0	0	0	0	0
Blackbanded Sunfish	0	0	0	0	0	0	0	0	0	2
Blue Catfish	0	1	0	0	0	0	0	0	0	0
Bluegill	4	14	1	5	7	32	62	13	4	31
Bowfin	24	26	26	38	40	39	26	5	5	4
Brook Silverside	1	2	4	5	4	0	3	1	2	6
Chain Pickerel	0	0	0	0	0	6	3	11	47	31
Channel Catfish	4	2	9	4	2	1	3	4	0	1
Coastal Shiner	1	2	3	24	41	0	0	1	5	6
Common Carp	1	3	2	0	0	0	0	0	0	0
Creek Chubsucker	2	0	0	0	0	0	0	1	3	0
Dollar Sunfish	1	1	3	5	3	5	5	7	1	31
Dusky Shiner	0	0	1	1	2	0	0	0	8	4
Eastern Mosquitofish	0	0	1	0	0	0	0	0	0	0
Flat Bullhead	0	0	0	0	0	0	0	0	6	1
Flathead Catfish	3	4	3	4	1	0	1	2	0	0
Flier	0	4	0	0	0	0	0	1	1	1
Gizzard Shad	0	0	0	0	0	1	2	0	0	0
Golden Shiner	2	0	3	0	1	0	0	4	0	0
Grass Carp	0	1	0	0	0	0	0	0	0	0
Ironcolor Shiner	1	0	0	0	0	0	0	0	1	0
Largemouth Bass	1	10	5	6	12	13	12	12	12	13
Longnose Gar	14	37	42	34	22	11	9	6	2	5
Margined Madtom	0	0	0	0	0	0	0	0	8	0
Mud Sunfish	0	0	0	0	0	0	0	0	0	1
Piedmont Darter	0	0	0	0	0	0	0	0	1	0
Pirate Perch	4	0	3	0	0	1	0	0	0	6
Pumpkinseed	0	0	1	0	1	3	2	4	0	0
Redbreast Sunfish	15	17	8	23	4	9	25	60	23	38
Redear Sunfish	4	13	14	5	15	14	15	12	1	0
Redfin Pickerel	1	2	1	2	4	4	2	13	3	47
Satinfin Shiner	0	0	0	0	0	0	1	0	0	0
Shorthead Redhorse	0	0	0	0	1	0	0	0	0	0
Snail Bullhead	0	0	0	0	0	0	0	0	2	0
Southern Brook Silverside	1	2	4	5	4	0	3	1	2	6
Spottail Shiner	0	1	2	1	0	0	0	0	1	3
Spotted Bass	2	0	0	0	1	0	4	6	9	3
Spotted Sucker	6	0	5	1	2	3	4	26	50	29
Spotted Sunfish	1	5	1	3	15	6	8	6	0	17
Swampfish	0	0	2	0	1	0	0	1	0	1
Tadpole Madtom	0	0	0	0	0	0	0	0	0	1
Taillight Shiner	6	0	0	0	0	0	0	0	1	0
Tessellated Darter	0	0	1	0	0	0	0	0	2	0
Thinlip Chub	2	0	7	0	2	0	0	0	0	0
Warmouth	0	3	0	0	1	1	7	4	0	4
Yellow Perch	0	0	0	0	0	3	2	6	6	2
Total species	23	20	26	18	24	18	21	24	26	26

TABLE 3. Aggregated catch (2015 and 2016) by low frequency (15 PPS) electrofishing site. The final row gives the number of species captured within each site.

	River kilometer																			
Species	29	30	33	36	37	44	46	47	50	52	98	99	101	102	103	104	105	106	150	202
Brown Bullhead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Channel Catfish	0	1	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0
Flat Bullhead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
Flathead Catfish	17	15	5	8	8	4	2	9	12	12	2	12	2	4	4	4	5	7	4	0
Margined Madtom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Snail Bullhead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Total species	1	2	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	1	1	4

TABLE 4. Estimated von Bertalanffy growth parameters. Quantiles represent the median (0.50; most credible estimate) and lower (0.05) and upper (0.95) 90% credible intervals of the joint posterior distribution.

Parameter	Quantiles		
	0.05	0.50	0.95
Bluegill			
L_∞	238	267	297
K	0.21	0.27	0.33
t_0	-1.11	-0.89	-0.69
Channel Catfish			
L_∞	649	756	873
K	0.14	0.22	0.31
t_0	-1.36	-0.46	0.24
Flathead Catfish			
L_∞	1,056	1,248	1,457
K	0.08	0.11	0.14
t_0	-0.80	-0.34	0.08
Largemouth Bass			
L_∞	480	523	570
K	0.21	0.27	0.33
t_0	-1.12	-0.72	-0.38
Redbreast Sunfish			
L_∞	271	300	333
K	0.17	0.22	0.28
t_0	-1.37	-1.05	-0.76
Redear Sunfish			
L_∞	333	378	430
K	0.21	0.27	0.34
t_0	-0.58	-0.36	-0.17

TABLE 5. Poisson log-linear modeled instantaneous total mortality (*Z*) and discrete annual mortality (*A*). Confidence interval for instantaneous total mortality was modeled using gamma distribution.

Species	Aged otoliths	Max age	*Z* (SE)		*Z* 90% CI	*A*
Bluegill	113	5	1.32	(0.31)	0.85–1.88	73%
Channel Catfish	26	13	0.41	(0.10)	0.26–0.59	34%
Flathead Catfish	113	13	0.32	(0.08)	0.20–0.46	27%
Largemouth Bass	60	17	0.39	(0.07)	0.28–0.51	32%
Redbreast Sunfish	162	8	0.50	(0.09)	0.36–0.66	39%
Redear Sunfish	69	6	0.69	(0.52)	0.10–1.68	50%

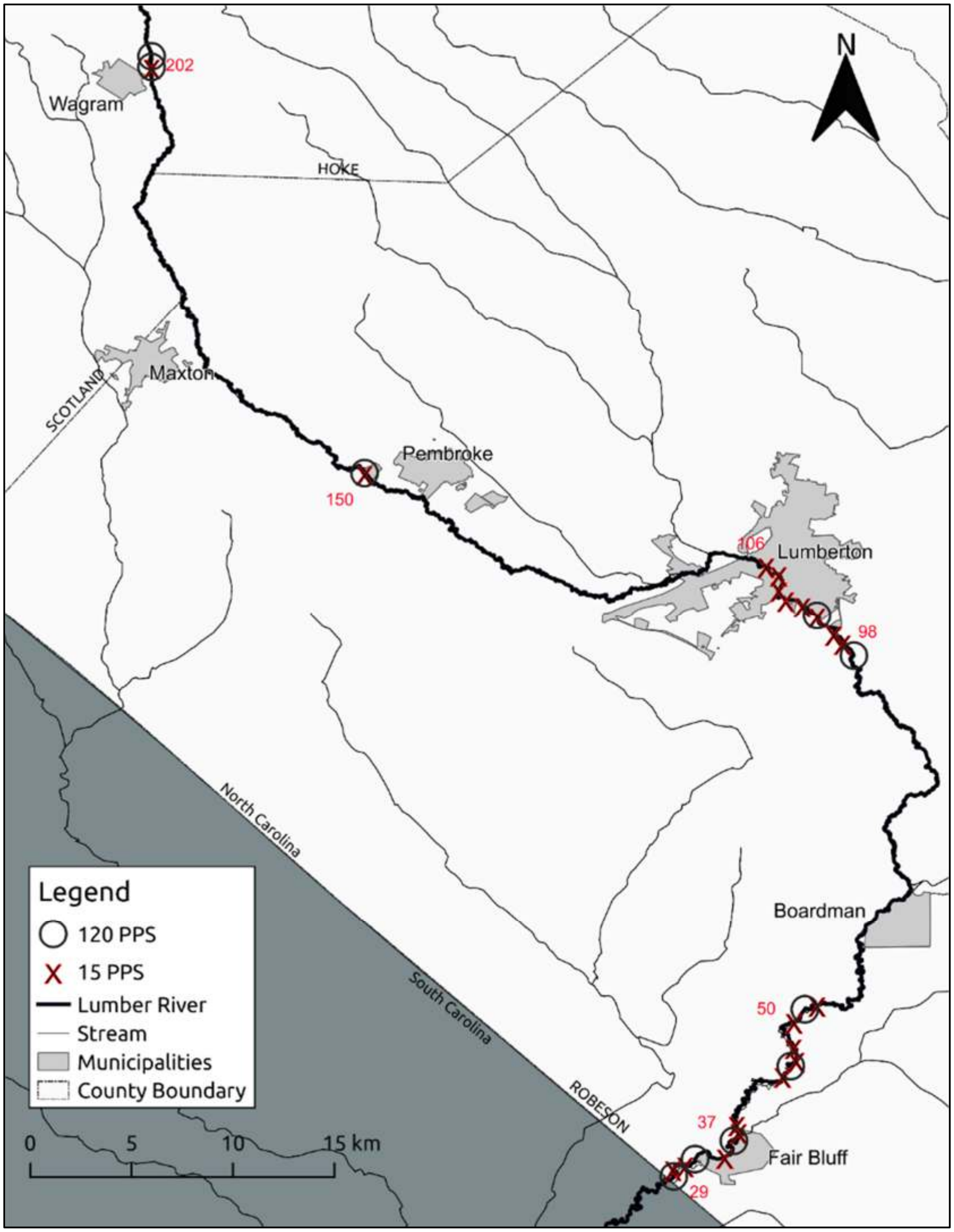

FIGURE 1. Lumber River sample sites in 2015 and 2016. Several sites are labeled (red) with their river kilometer to provide orientation to sites referenced in text.

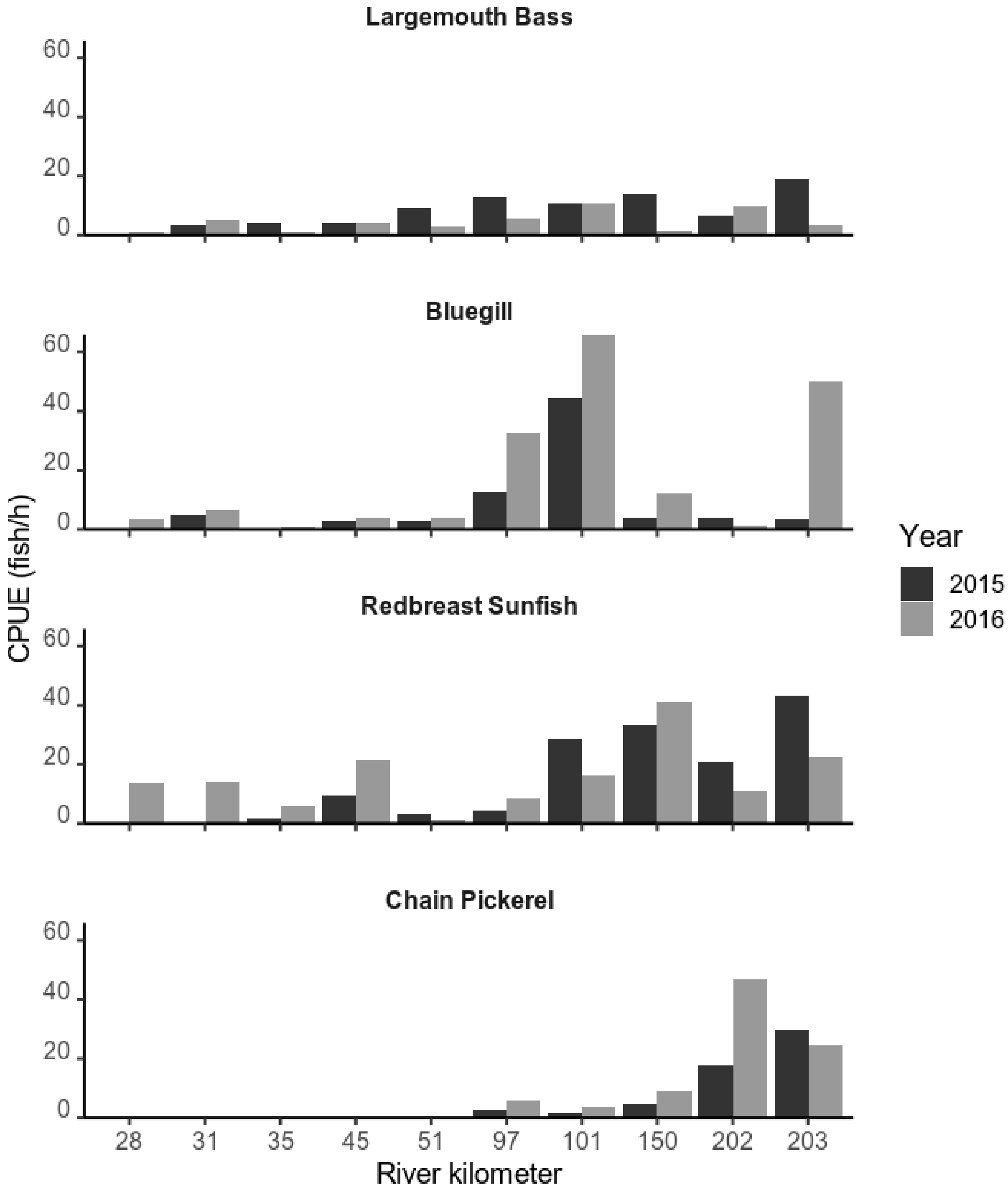

FIGURE 2. Catch per unit effort by site (river kilometer) and year for the four Inland Game Fish with the greatest catch in the high frequency (120 PPS) electrofishing sites. The x-axis is ordered left to right, downstream to upstream.

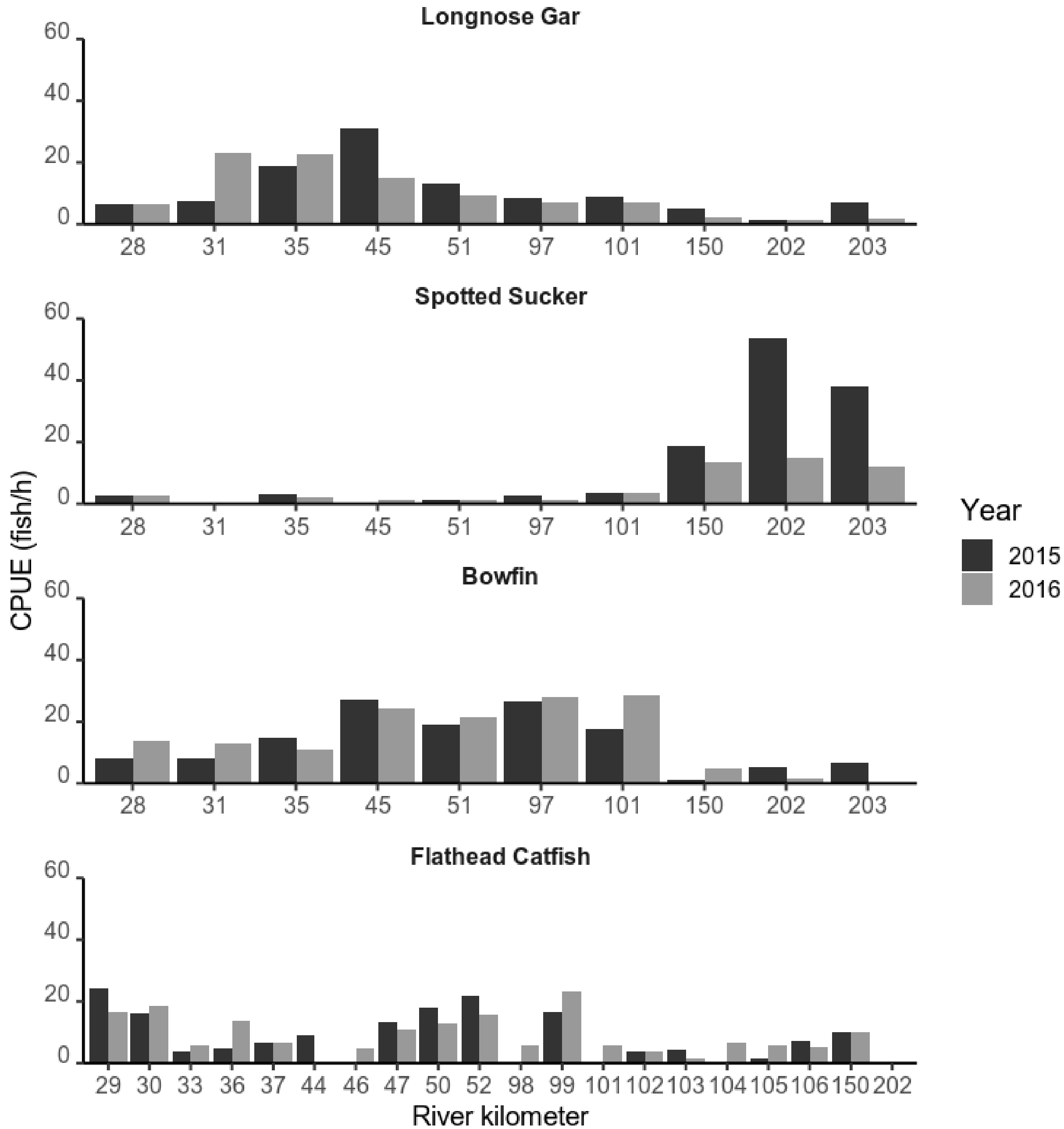

FIGURE 3. Catch per unit effort by site (river kilometer) and year for the four nongame fish with the greatest catch. Flathead Catfish sites and effort are from low frequency (15 PPS) electrofishing; other species depict effort from high frequency (120 PPS) electrofishing sites.

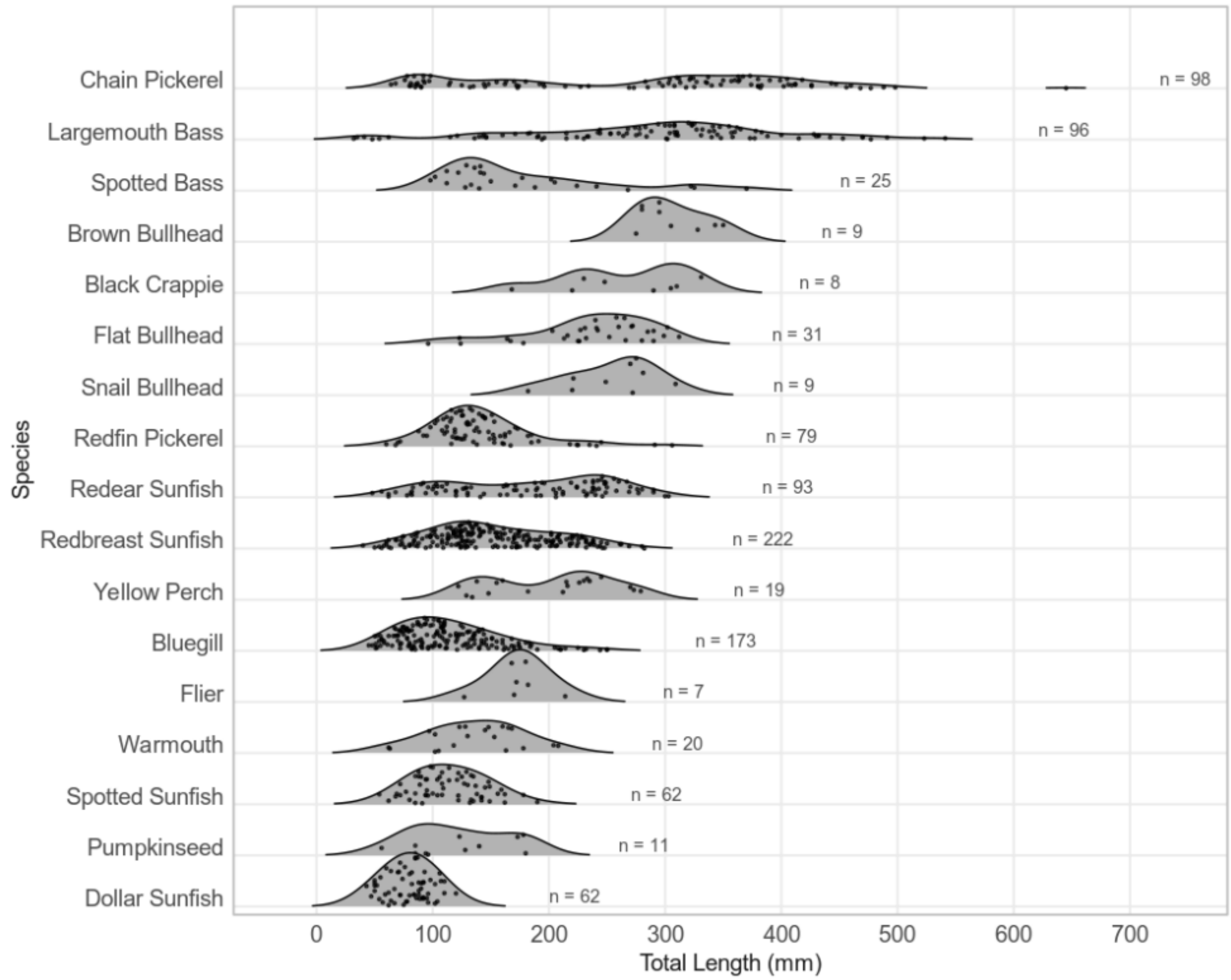

FIGURE 4. Density plots of Inland Game Fish with five or more collected individuals in descending order by maximum size of the largest individual. The sample size is denoted to the right of each size distribution.

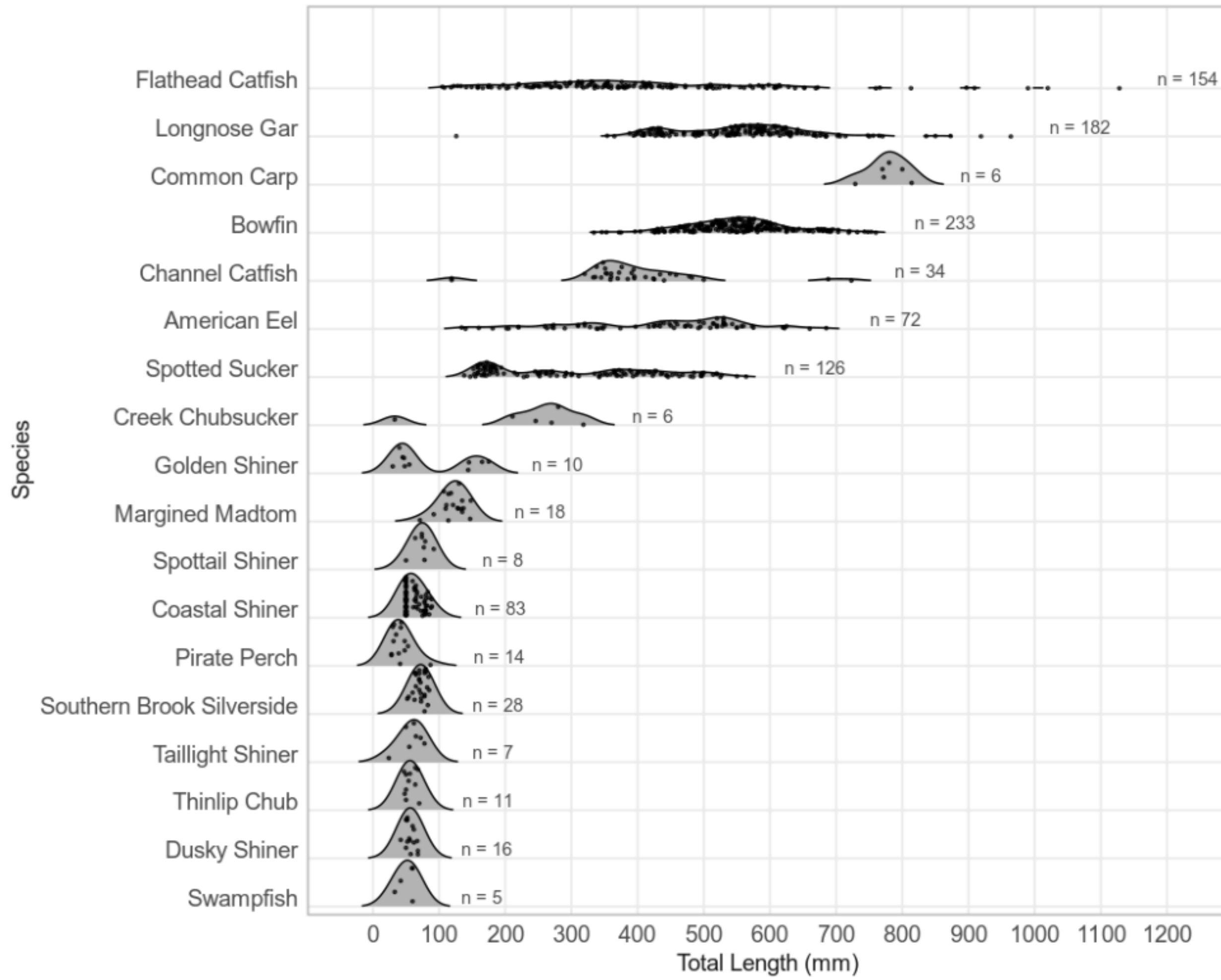

FIGURE 5. Density plots of nongame fish with five or more collected individuals in descending order by maximum size of the largest individual. The sample size is denoted to the right of each size distribution.