NORTH CAROLINA WILDLIFE RESOURCES COMMISSION
INLAND FISHERIES DIVISION

JOB STATEMENT

Date of Last Revision 5/18/2020

(SFR Grant F108, Cost Center 1141-5301-2700; 1141-5301-2800; 1141-5301-2900)

Title: Initiating a Standardized Monitoring Protocol to Evaluate Riverine Smallmouth Bass Populations in Western North Carolina.

Need: Smallmouth Bass are widely distributed throughout western North Carolina, where native populations are found in interior basin drainages and introduced populations are found on the Atlantic slope drainages. These populations are ecologically important and provide popular fisheries. Climate change, illegal introduction of non-native congeners (e.g., Alabama Bass), and land use changes are a few factors that potentially threaten riverine Smallmouth Bass populations. Comprehensive riverine Smallmouth Bass data were first collected from 2007–2009; however, standardized monitoring data are lacking to assess these emerging concerns and provide current biological data.

Objective: Collect standardized population data from riverine Smallmouth Bass populations using angling to provide information that informs conservation and management decisions.

Expected Results and Benefits: Standardized monitoring data are needed to determine resiliency of riverine Smallmouth Bass populations to climate change, invasive species, changing land use, increased fishing pressure, etc. Standardized data will also provide annual, transferrable information to stakeholders regarding riverine Smallmouth Bass fisheries, as well as provide comparable regional data for fishery managers.

Approach: Riverine Smallmouth Bass collections using angling will begin in summer 2020 (June–September) and continue annually thereafter through 2025, with a goal of collecting either 150–200 fish or expending five days of effort (40–50 total man-hours) from at least one stream per District per year in the Mountain Region. During winter (January–February) 2026, a regional meeting will be held to present 2020–2025 collection data, review riverine Smallmouth Bass standardized monitoring protocol, and discuss future collection efforts.

Location: Mountain Region riverine resources in western North Carolina with viable Smallmouth Bass fisheries.

NORTH CAROLINA WILDLIFE RESOURCES COMMISSION
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PROJECT NARRATIVE

Initiating a Standardized Monitoring Protocol to Evaluate Riverine Smallmouth Bass Populations in Western North Carolina

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INTRODUCTION

The Smallmouth Bass *Micropterus dolomieu* is native to interior eastern North America and west of the Appalachians (Etnier and Starnes 1993) but has been widely introduced in North Carolina east of the Blue Ridge Mountains in the Piedmont physiographic province (Mickey 1980; Menhinick 1991; Goodfred et al. 2012). Western North Carolina harbors an abundance of both native and non-native ecologically important Smallmouth Bass fisheries; however, until recently, information on North Carolina Smallmouth Bass populations was extremely limited. Data sets from only a few riverine resources (Mickey 1980; Hodges 2000; Hodges 2004; Hodges 2006) formed historical management philosophies. Scarcity of historical data combined with increased interest in Smallmouth Bass angling led the North Carolina Wildlife Resources Commission (NCWRC) to initiate a comprehensive evaluation of these important fishery resources. Goodfred et al. (2012) examined the geographic extent and population dynamics of western North Carolina Smallmouth Bass populations and identified 42 stream reaches from nine river basins with fishable populations. In general, riverine Smallmouth Bass populations exhibited slow growth rates, moderate to high mortality, and poor condition. Length, weight, and age data were input into an age-structured model (Slipke and Maceina 2001) to simulate various harvest regulation effects on select Smallmouth Bass populations. Size structure and yield predictions from modeled simulations showed populations benefited from an increased minimum size limit at moderate levels of fishing and natural mortality. Based on these findings, the NCWRC increased the statewide Smallmouth Bass size limit from 305-mm TL to 356-mm TL on August 1, 2012.

Goodfred et al. (2012) also acknowledged the need for standardized riverine Smallmouth Bass population monitoring to inform future conservation and management decisions. They recommended establishment of standardized monitoring protocols in riverine resources to evaluate harvest regulation changes, increased fishing pressure, habitat alterations, and other management activities. However, since 2009, limited riverine Smallmouth Bass data have been collected (Hodges 2017a; Hodges 2017b; Bushon 2019; Wheeler and Bushon 2019), and only a single, standardized monitoring effort using angling since 2011 has been established on the North Toe River in Mitchell and Yancey counties (Table 1). Standardized monitoring can facilitate resilient management approaches to address uncertainties in freshwater systems by detecting spatial and temporal changes to fish population metrics resulting from climate change impacts (Jimenez Cisneros et al. 2014), invasive species introductions (Love and Newhard 2012; Dorsey and Abney 2016), and changing land use and associated environmental stressors (Taylor et al. 2019). These uncertainties and possible threats have been shown to impact Smallmouth Bass populations nationwide.

Climate change is one of many factors influencing fish populations and their response to fishery management (Hansen et al. 2015). Casselman et al. (2002) summarized over two decades worth of standardized monitoring gill-net data in Lake Ontario, New York and found positive correlations between Smallmouth Bass year-class strength and warming July–August water temperatures. They concluded that a 1°C increase in water temperature from global warming would increase Smallmouth Bass year-class strength almost 2.5-fold and a 6-fold change in year-class strength given a 2°C temperature increase. Documented consequences of the northern expansion and changes in spawning phenology of non-native Smallmouth Bass in Ontario's inland lakes facilitated by climate change have resulted in the need for altered harvest regulations to adapt to these changes (Paukert et al. 2016). In general, researchers have concluded that Smallmouth Bass will increase their range (Sharma et al. 2007), relative abundance (Casselman et al. 2002), and growth rates (Pease and Paukert 2014) as a result from a warmer climate. Additionally, storm severity and frequency increases, altering precipitation patterns and flow regimes due to climate change, are projected to greatly affect riverine black bass populations in the southeastern United States (Sievert et al. 2016). Because riverine Smallmouth Bass recruitment is heavily dependent on growth and flow patterns during the first year of life (Lukas and Orth 1995; Smith et al. 2005), flow regimes driven by altered precipitation patterns from a warmer climate will likely affect the stability of these populations (Taylor et al. 2019).

Arguably the most immediate threat to the conservation of black bass diversity is the introgressive hybridization that results from the introduction of non-native congeners (Taylor et al. 2019). Although some management agencies have ceased stockings of non-native black bass, anglers have continued to introduce species like Alabama Bass *Micropterus henshalli* across river basins in the southeastern United States (Leitner et al. 2015). In North Carolina, angler introductions of Alabama Bass in the last two decades have been shown to displace resident Largemouth Bass *Micropterus salmoides* populations (Goodfred 2011; Dorsey and Abney 2016; Goodfred 2019) and yield a high degree of introgressive hybridization with Smallmouth Bass populations in reservoirs (NCWRC unpublished data). Introgression with non-native congeners threatens the integrity of populations of nearly every endemic bass form (Koppelman 2015). However, little is currently known regarding the spatial extent of introductions of Alabama Bass and their potential impacts to native and non-native riverine Smallmouth Bass populations in North Carolina.

Another uncertainty with Smallmouth Bass populations in North Carolina riverine systems is changing land use impacts resulting from human population expansion. Agricultural, industrial, and municipal pollutants causing endocrine disruption present an emerging concern of intersex condition in black bass populations (Bringolf et al. 2015). Environmental stressors (e.g., high nutrient loads and elevated water temperatures) in the Susquehanna River, Pennsylvania resulted in severe disease-related mortalities of young-of-the-year Smallmouth Bass during late spring and summer, which led to significant population metric changes since

2005 (Walsh et al. 2018). Additionally, land use changes and human population expansion have been linked to the extirpation of some riverine endemic black bass populations in Alabama (Stormer and Maceina 2009). Changing land use and associated environmental stressors is often a complex issue dealing with multiple environmental and ecological alterations (Taylor et al. 2019); however, standardized monitoring can help detect the emergence of and track these expected changes (Paukert et al. 2016).

While detecting and tracking the emergence of population changes is worthwhile for any standardized monitoring approach, the practical benefits for fishery managers are many. Standardized monitoring has been conducted on native and non-native salmonids in western North Carolina mountain streams for decades (Borawa et al. 2001), and recently, a less intensive (i.e., single-pass electrofishing) standardized monitoring approach was initiated to inform conservation and management decisions (NCWRC 2012). Similarly, annual sportfish monitoring by the NCRWC in North Carolina reservoirs and large coastal rivers is conducted statewide regularly to evaluate population dynamics, track invasive species impacts, and provide current information to stakeholders (Oakley and Dorsey 2013; Ricks and Buckley 2019). However, limited riverine Smallmouth Bass population data have been collected since 2009 (see above) in western North Carolina, and data that have been collected are generally not standardized and fail to provide meaningful among-population comparisons. By collecting standardized data regionally, biologists will be able to evaluate riverine Smallmouth Bass populations and make informed conservation and management decisions. Standardized information gathered collectively using angling in riverine resources will also provide current, relatable fish population metrics and resource information to stakeholders of North Carolina and may assist with the development of future outreach efforts and access opportunities. Additionally, angling has been shown to be an effective stock assessment tool for riverine Smallmouth Bass populations in North Carolina given the complex habitats generally unconducive to traditional electrofishing gear (Goodfred et al. 2012) when sufficient effort is expended to bolster sample sizes (Hodges 2017a).

METHODS

Study Area.—Smallmouth Bass will be collected from riverine resources in the Mountain Region that contain robust populations (Figure 1).

Riverine Smallmouth Bass Collections.—Smallmouth Bass collections using angling gear will begin in summer (June–September) 2020 and continue annually thereafter through 2025, with a goal of collecting either (i.e., whichever reached first) 150–200 fish or expending five days of angling effort (40–50 total man-hours) from at least one stream per District per year (three streams total for Mountain Region per year). Sample size was determined using North Toe River riverine Smallmouth Bass monitoring data (Table 1) that would detect a 10–15% difference in annual proportional size distribution (PSD) given a statistical power of 0.80 and Type I error rate of 0.05 and 0.10, respectively (Sokal and Rohlf 1995; Uitenbroek 1997; Table 2). Since fish will be collected using angling, careful consideration of weather, optimal river conditions (e.g., clarity and water temperature), and skilled assistance should be exercised for each survey. Artificial lures fished on spinning or casting gear rigged with ≥ 1.8- to 3.6-kg test monofilament or fluorocarbon line only will be used for collections. Primary artificial lures recommended include soft plastic baits (tube jigs, fluke jrs, swim baits, senkos, worms, lizards, curly tail grubs, etc.), hard baits (small jerk baits, spinners, etc.), and topwater baits (buzzbaits, walking baits, and poppers). Effort (man-hours) will be determined as time solely spent angling beginning with the first cast and concluding with the last cast of each survey. Time spent not angling (e.g., measuring and weighing fish for live release, walking back to the vehicle after a wade fishing survey, driving to multiple access locations to find wadeable fishing access, etc.) should be tracked and subtracted from the survey angling effort to determine the overall angling effort per survey. For example, if two anglers float a section of river in a canoe, fish from 0700 to 1500 (16 man-hours), and spend one hour recording population data, the overall angling effort for the survey would total 14 man-hours. Similarly, if two anglers conduct a wade fishing survey from 0800 to 1200 (8 man-hours) but spend one hour driving to multiple access locations along the river and walking back to their vehicle at the conclusion of each wadeable reach, the overall effort for the survey would total 6 man-hours. All Smallmouth Bass collected will be measured for total length (TL; mm), weighed (g), and released. The need for age and growth information will be determined by District discretion; however, relative abundance, lengths, and weights should be recorded for all surveys. When age and growth data are desired, sagittal otoliths will be extracted and processed according to typical processing and age assignment methodologies used in the Mountain Region (Heidinger and Clodfelter 1987; Besler 1999; Allen et al. 2003; Buckmeier and Howells 2003), considering date of collection within the growing season and associated annulus formation (Goodfred et al. 2012).

Data Analysis.—Catch-per-unit-effort will index relative abundance and will be calculated as the number of Smallmouth Bass collected per survey divided by the overall angling effort (man-hours). Length-frequency histograms will be constructed to visually assess size distributions of riverine Smallmouth Bass populations. Proportional size distribution and relative size distribution values of preferred- (PSD-P), memorable- (PSD-M), and trophy- (PSD-T) sized fish will be calculated for each collection as described by Gabelhouse (1984) and modified by Guy et al. (2007). Relative weight (W_r) will be used to index fish condition and calculated for Smallmouth Bass $\geq$ 150 mm TL using the standard weight (W_s) equation described by Kolander et al. (1993). If age data are collected, age-distribution histograms displaying age classes will be constructed for each survey. When the data permit, Smallmouth Bass growth (mean length at age) will be described using the von Bertalanffy growth model (von Bertalanffy 1938). Where possible, the instantaneous total annual mortality rate (Z) will be estimated using catch curve methodologies as described by Miranda and Bettoli (2007). Annual survival (S) will be calculated as $S = e^{-Z}$, and total annual mortality (A) will be calculated as 1 – S (Ricker 1975).

Regional Data Summation, Archiving, Reporting, and Monitoring Protocol Review.—Districts will send their raw or analyzed riverine Smallmouth Bass standardized monitoring data to the designated regional representative (D. Goodfred) for compilation by the end of each calendar year (i.e., December 31st). The regional representative will then organize and disseminate the summarized data to the Districts, as well as archive monitoring data on an annual basis. Management reporting for 2020–2025 standardized riverine Smallmouth Bass collections, produced by the regional representative in conjunction with all interested biologists, will be presented at a regional meeting held during winter (January–February) 2026. Riverine Smallmouth Bass standardized monitoring protocol and future collection efforts will also be reviewed and discussed during this meeting (Table 3).

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TABLE 1.—Monitoring population metrics for Smallmouth Bass (SMB) collected during June–October 2011–2019 standardized angling surveys, North Toe River, North Carolina. Catch (N), effort (man h), catch-per-unit-effort [CPUE (fish/man h)] with associated standard error (SE), total length range, mean total length, proportional size distribution (PSD), PSD-preferred (P), and PSD-memorable (M) values with 95% confidence intervals in parentheses are shown by sample year.

Year	Species	N	Effort	CPUE (SE)	Range (mm)	Mean (mm)	PSD	PSD-P	PSD-M
2011	SMB	210	40.1	5.2 (1.0)	153–419	254	31 (24–37)	3 (1–5)	
2012	SMB	182	42.0	4.3 (1.3)	155–430	255	30 (23–36)	5 (2–8)	1 (0–2)
2013	SMB	172	24.5	7.0 (1.3)	127–449	247	23 (16–29)	6 (2–10)	1 (0–2)
2014	SMB	176	50.0	3.5 (0.7)	160–392	247	24 (17–30)	6 (2–9)	
2015	SMB	159	45.3	3.5 (0.6)	74–450	261	32 (25–40)	2 (0–4)	1 (0–2)
2016	SMB	126	26.0	4.8 (0.4)	151–415	240	23 (16–31)	3 (0–7)	
2017	SMB	104	24.0	4.3 (1.0)	159–400	243	18 (11–26)	6 (1–11)	
2018	SMB	125	24.0	5.2 (0.5)	162–378	226	10 (4–15)	3 (0–6)	
2019	SMB	207	45.5	4.5 (0.4)	149–400	239	14 (10–19)	1 (0–3)	

TABLE 2.—Sample size needed to compare two proportions given a statistical power of 0.80 and Type I error rate (α) of 0.05 and 0.10. P_1 is the initial proportional size distribution (PSD) value and d is the difference (P_2-P_1). Sample size range (N = 150–200) determined for riverine Smallmouth Bass standardized monitoring protocol was derived considering the mean P_1 value of 0.23 and associated 95% confidence intervals (0.17–0.29) calculated from Table 1 needed to detect a 10–15% d in annual PSD.

		d							
P_1	α	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40
0.10	0.05	543	158	79	49	34	25	20	16
	0.10	396	115	58	36	25	18	14	11
0.20	0.05	866	232	109	65	43	31	23	18
	0.10	632	170	80	47	31	22	17	13
0.30	0.05	1,089	282	129	74	48	34	25	19
	0.10	795	206	94	54	35	25	18	14
0.40	0.05	1,214	307	137	77	49	34	24	18
	0.10	886	224	100	56	36	25	18	13
0.50	0.05	1,238	307	134	74	46	31	22	16
	0.10	904	224	98	54	34	22	16	11

TABLE 3.—Mountain Region work schedule for riverine Smallmouth Bass standardized angling monitoring protocol, 2020–2026.

Year	Activity	Month	Effort (man-hour)	N	Data Collected*	Data Due**
2020	One stream surveyed per District	June–September	40–50	150–200	Total lengths, weights, and relative abundance	12/31/2020
2021	One stream surveyed per District	June–September	40–50	150–200	Total lengths, weights, and relative abundance	12/31/2021
2022	One stream surveyed per District	June–September	40–50	150–200	Total lengths, weights, and relative abundance	12/31/2022
2023	One stream surveyed per District	June–September	40–50	150–200	Total lengths, weights, and relative abundance	12/31/2023
2024	One stream surveyed per District	June–September	40–50	150–200	Total lengths, weights, and relative abundance	12/31/2024
2025	One stream surveyed per District	June–September	40–50	150–200	Total lengths, weights, and relative abundance	12/31/2025
2026	2020–2025 data reporting and regional meeting	January–February				

* need for age and growth data using sagittal otoliths determined annually by District discretion

** regional representative annually analyses/summarizes, archives, and disseminates data to Districts

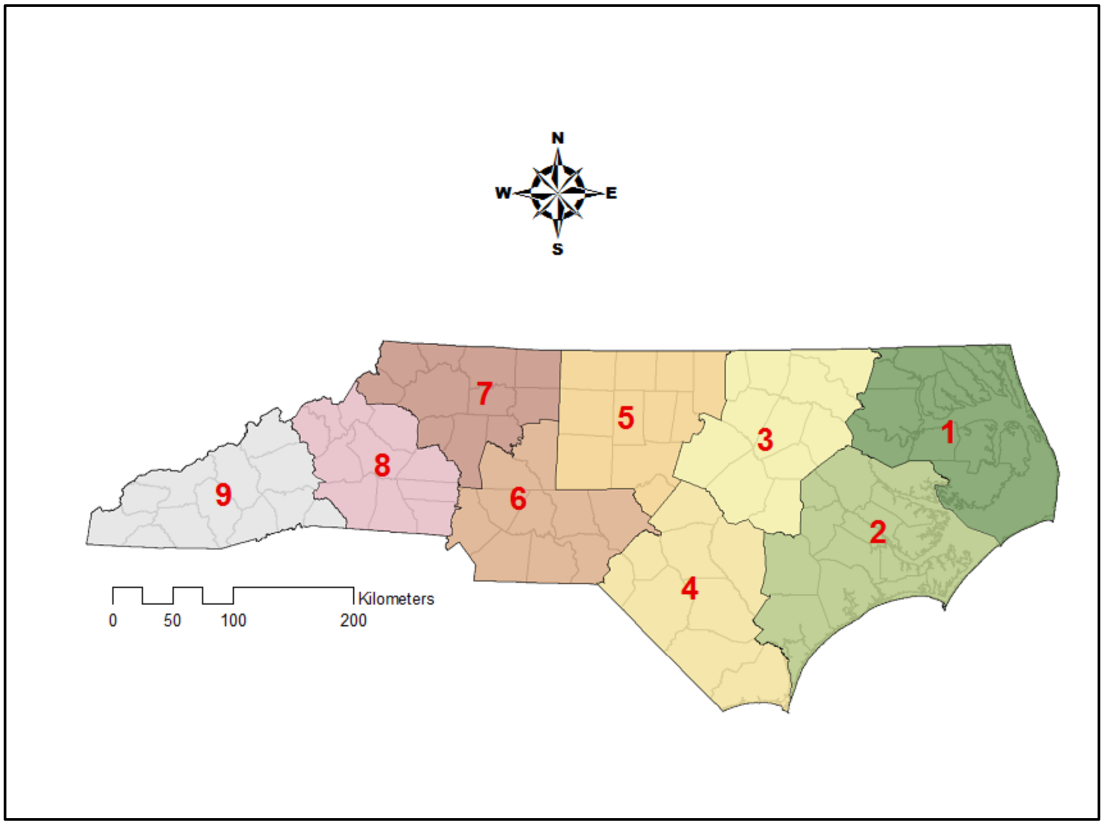

FIGURE 1.—Map of North Carolina, with the nine North Carolina Wildlife Resources Commission management Districts and associated jurisdictional counties. Riverine Smallmouth Bass collections for standardized monitoring will occur in the Mountain Region, which encompasses Districts 7, 8, and 9.