Spotted Bass Population Structure and Diet in Wadeable and Non-wadeable Streams Draining the Lake Pontchartrain Basin

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Abstract: Spotted bass (*Micropterus punctulatus*) provide popular recreational fisheries in southeastern U.S. streams. We studied spotted bass population structure and diet from wadeable (< 1 m deep on average, $n = 174$, 21 sites) and non-wadeable ($n = 498$, 32 sites) reaches of the Lake Pontchartrain Basin in Mississippi and Louisiana to determine if populations should be managed separately by stream size. Sampling occurred April–November 2009–2012 by hook-and-line angling, boat-mounted electrofishing, and seines. Size structure was similar between stream type and with few quality-sized fish (PSD ≤ 24). Spotted bass relative weight (W_r) was higher in non-wadeable streams (mean $W_r = 91$) than in wadeable streams (mean $W_r = 85$). Larger spotted bass (> 200 mm TL) consumed more crayfish and fish, other vertebrates, and multiple types of aquatic and terrestrial insects by number. Crayfish and fish were eaten more frequently in wadeable streams than in non-wadeable streams. Maximum theoretical length (L_{inf}) was greater for wadeable stream fish ($L_{inf} = 399$ mm TL) than non-wadeable stream fish ($L_{inf} = 356$ mm TL), but growth rates were similar between stream types. Sexual maturation rates for both sexes combined were similar with 50% of individuals maturing at 195 mm TL and 202 mm TL in non-wadeable and wadeable streams, respectively. Total annual mortality (A) estimated from weighted catch curves was 16% and 17% for non-wadeable and wadeable stream populations, respectively. Because population structure was similar, we recommend that spotted bass from wadeable and non-wadeable coastal plain streams be managed with consistent regulations.

Key words: *Micropterus punctulatus*, rivers, growth, mortality, maturation, diet

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Spotted bass (*Micropterus punctulatus*) provide a popular recreational fishery resource in southeastern U.S. free-flowing river basins. The species' native range is from the Mississippi River drainage in West Virginia and southern Ohio to southwestern Kansas. In addition, they occur in coastal plain streams draining the Gulf of Mexico east to the Choctawhatchee River, Alabama and Florida, and west to the Guadalupe River, Texas (Warren 2009). Those from Gulf-coast drainages between the Mobile and Apalachicola basins have been recently proposed as a new species of black bass (Tringali et al. 2015). In Louisiana, spotted bass can be caught by anglers in wadeable headwater streams or in non-wadeable rivers, yet these fisheries are thought to be lightly exploited, regardless of a stream's size or its position in the basin (T. Morrison, Louisiana Department of Wildlife and Fisheries, personal communication). They are managed state-wide using daily creel limits or length limits in concert with other *Micropterus* species collectively as "black bass" because it is difficult for anglers to distinguish among the species.

In river ecosystems, stream size can influence the food web dynamics that affect growth, recruitment, and mortality of fisheries resources. In any particular river basin, small wadeable streams (generally Strahler orders 1-5-m and < 1-m deep) will exhibit lower net primary productivity than the larger non-wadeable streams (Vannote et al. 1980, Junk et al. 1989, Thorp and DeLong 1994). However, allochthonous sources of organic matter from riparian areas can subsidize internal autochthonous energy inputs in wadeable streams (Fausch et al. 2002, Eros et al. 2012). Nevertheless, secondary production of aquatic biomass, such as zooplankton and benthic invertebrates, increases as a function of stream size. Therefore, total fish biomass within a river basin should also be lower in wadeable streams relative to non-wadeable streams as a consequence of this positive relationship between habitat volume and food web productivity (e.g., changes in food chain length and g m^{-2} of consumers over time; see Xiao et al. 2015).

Whereas population assessments of spotted bass have been performed on reservoir or impounded river populations (e.g., Buynak et al. 1991, Eggleton et al. 2012), very little work has been published on population structure of this species in free-flowing river systems. Because less energy is available to tertiary consumers in wadeable stream food webs, it is logical to hypothesize that population dynamics of spotted bass in wadeable streams should be different than populations in non-wadeable rivers and impounded portions of rivers where more energy is available to top predators (Xiao et al. 2015). The purpose of our study was to determine if spotted bass populations should be managed differently with respect to stream size based on population dynamics. Our objectives

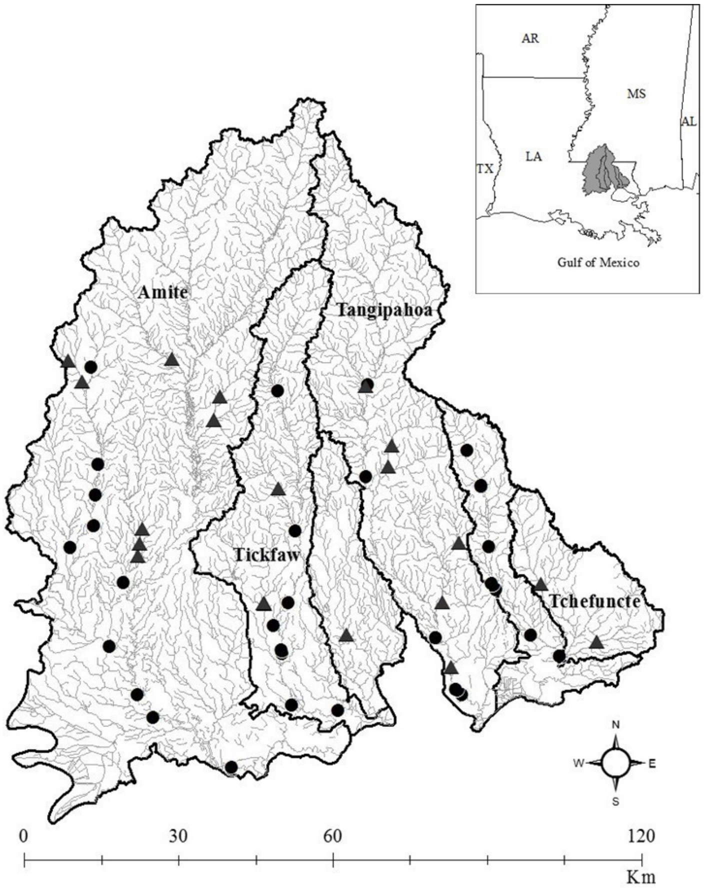

Figure 1. Locations of non-wadeable (circles) and wadeable (triangles) stream samples (left image) for electrofishing, hook-and-line, and seine sampling of spotted bass in the Lake Pontchartrain Basin (right image) located in southwest Mississippi and southeast Louisiana. There were four sub-basins (Amite, Tickfaw, Tangipahoa, and Tchefuncte river systems).

were to compare (1) length frequency and population structure, (2) diet composition, (3) age distribution and individual growth rate, and (4) total annual mortality between spotted bass populations in wadeable and non-wadeable free-flowing streams in the Lake Pontchartrain Basin of Mississippi and Louisiana.

Study Area

The Lake Pontchartrain Basin (LPB) is located in southwest Mississippi and southeastern Louisiana and has an area of 24,080 km^2 (Figure 1). Aquatic habitats are diverse in the basin, including rivers, cypress-tupelo swamps (*Taxodium-Nyssa* spp.), freshwater and brackish marshes, backwater sloughs, artesian spring-fed creeks, bayous, and the oligohaline Lake Pontchartrain (Lopez 2009, Martinez and Penland 2009). This study was conducted in four of the five major sub-basins that drain into the north shore of Lake Pontchartrain, and included the Amite River, Tickfaw River, Tangipahoa River and Tchefuncte River sub-basins (Figure 1). Sub-basins were sampled in proportion to their drainage size to capture the representative available habitat in the LPB. There were 32 sites sampled from non-wadeable streams and 21 sites sampled from wadeable streams (Figure 1). For our study, a non-wadeable stream site was defined as having a mean depth ≥1 m and a wetted width >10 m; those streams smaller and shallower were considered wadeable. In general, non-wadeable streams were more turbid due to suspended sediments and phytoplankton and had less large woody debris (LWD) but more deep-pool habitat (>2 m) and open riparian canopies (Alford 2014). Wadeable streams contained a mix of sand, silt, and gravel substrates with clear water, shallow riffle-run sequences, few deep pools, closed or open canopies, and greater frequencies of LWD in the channel (Alford 2014).

Methods

Sampling and Data Collection

Spotted bass were sampled April through November 2009–2012. Fish were captured by hook-and-line angling, boat-mounted electrofishing, and seines. Hook-and-line sampling was conducted by 2–4 anglers at a site. A site was fished continuously for 2–3 hours with anglers either wading upstream (wadeable sites) or boating downstream (non-wadeable sites). Spotted bass were angled using artificial lures with spinning and baitcast gear. Occasionally, fly fishing gear was used from a kayak in non-wadeable sites. Boat-mounted electrofishing was used in non-wadeable sites with a Smith-Root 7.5 GPP model electrofisher (Smith-Root, Inc., Seattle, Washington) at 60 Hz pulsed DC with power output maintained at 6–8 amps. Electrofishing occurred along banks in a downstream direction for runs lasting 450-900 sec. To sample age-0 fish (<100 mm TL) and increase precision of growth models, seine hauls were used with 3.0- x 1.8-m nylon seines at wadeable sites and a 6.0- x 1.8-m seine at non-wadeable sites. All spotted bass collected were placed on ice and returned to the LDWF laboratory, where they were weighed (g), measured (total length, mm), and had otoliths and stomachs removed for further analyses.

Sagittal otoliths were removed, sectioned, polished, and viewed under light microscopy for aging. Standard protocols were used to process and age sectioned otoliths following VanderKooy and Guindon-Tisdel (2003). Two independent readers counted annuli and recorded age for each fish. Discrepancies were resolved by discussion and subsequent agreement among the two readers; or if necessary, a third reader was used to resolve differences. Using an 1 April birth date, biological ages were assigned to fish based on the annuli and the date they were captured, whereby each month of capture following 1 April added another 1/12 of a year to the age. For example, if a fish was captured in July and there were four annuli, then the fish was assigned a biological age of 4.25. A subset of pre-spawned fish were sexed and defined as sexually immature or mature, based on relative size of gonads and presence of milt or eggs.

Statistical Analyses

To describe size-structure of spotted bass, length- and age-frequency histograms were developed from hook-and-line samples from both stream types as well as from electrofishing samples from non-wadeable streams. Kruskal-Wallis tests were used to determine if significant differences existed in length- and age-frequency of fish from sampled by hook-and-line from each stream type using SAS Enterprise Guide v. 6.1 (SAS Institute 2013). To compare size-structure indices between stream types, proportional size structure indices (PSD, PSD-P, PSD-M, and PSD-T) and 95% confidence intervals were calculated, as well as mean relative weight (W_r) from hook-and-line samples. All size-structure indices mean W_r were calculated using FAMS software v. 1.64 (Slipke and Maceina 2014) using the size categories for spotted bass listed in Neumann et al. (2012).

To assess diet, lowest practical taxonomic groups were assigned to diet items by fish size group (100-mm size groups) to examine spotted bass ontogenetic diet shifts. Diets items were placed into broader categories for comparisons. All species of fishes and crayfish consumed were placed into single categories (fish and crayfish, respectively). Other categories included grass shrimp (*Paleomonetes* spp), other vertebrates (reptiles, mammals, and amphibians), aquatic insects (those with larval aquatic life stages such as mayflies, caddisflies, dragonflies, etc.), other insects (those that are terrestrial in all life stages such as arachnids, hymenopterans, and lepidopterans), other invertebrates (annelid worms, unidentifiable insects, and unidentifiable non-insect arthropods), and plant (included filamentous algae, detritus, and macrophytes). Size-specific diets were described graphically by calculating percent composition of prey items by number as well as percent occurrence (i.e., frequency of a prey category). A Sum-F multivariate test was calculated in PC-ORD v. 6.15 (McCune and Mefford 2011) to compare the similarity in frequencies of diet categories between stream types.

To compare sexual maturation rates between stream types, logistic regression models were run on binary sexual maturity data (i.e., mature vs immature) as the response variable and total length (TL) as a predictor variable. The total length at which 50% of fish were classified as mature (LM50 value) was estimated from logistic regression models using TableCurve 2D software v. 5.01 (Systat Software, Inc., San Jose, California).

To assess individual growth rates, a von Bertalanffy (1957) model was developed using mean length-at-age from both stream types (all gears). Difference in growth between stream types was compared using analysis of covariance (ANCOVA) over ages 1–6 as the covariate and mean length-at-age as the response (Sammons and Maceina 2009). Ages were ln-transformed to meet error assumptions associated with linear regression. The ANCOVA was conducted using PROC GLM (SAS Institute 2013).

Weighted catch-curve regressions were used on $\log_e$-transformed number-at-age for hook-and-line samples only to estimate total instantaneous mortality (Z) of stocks from the two stream types. Regressions were run over ages 2–9 for non-wadeable stream fish and 3–11 for wadeable stream fish. Total annual mortality (A) was then calculated as $A = 1 - e^{-Z}$ for stocks from each stream type. We only used angling data to estimate mortality because our primary objective was to compare the two stream types, thus using the electrofishing data from the non-wadeable stream fish would not be comparable with wadeable stream fish. Weighted catch-curve mortality and von Bertalanffy growth parameters were calculated using FAMS software v. 1.64 (Slipke and Maceina 2014). All statistical tests were considered significant at $P < 0.05$.

Results

Length-frequency histograms (Figure 2) show that spotted bass from non-wadeable sites sampled by electrofishing were smaller than those sampled by hook-and-line (Kruskal-Wallis test, $X^2 = 82.1$, df = 1, $P < 0.001$). Size distribution comparisons of stream type revealed that, for hook-and-line samples only, fish from non-wadeable streams were generally smaller than fish from wadeable streams (Kruskal-Wallis test, $X^2 = 10.5$, df = 7, $P = 0.02$). Non-wadeable stream fish from hook-and-line samples averaged 221 mm TL (modal length group = 203 – 229 mm), whereas fish from wadeable streams averaged 253 mm TL (modal length group = 255 – 279 mm). Size-structure indices indicated a low number of quality- and preferred-size fish in the two stream types, and no fish were captured that were memorable- or trophy-size (Table 1). Size-specific mean W_r for non-wadeable stream populations ranged 89–94 (Table 1), while W_r of spotted bass from wadeable streams ranged 82–87 (Table 1).

There were 498 fish aged from non-wadeable sites (hook-and-line, electrofishing, and seine gear), and 174 fish aged from wadeable stream sites (hook-and-line and seine gear). Initial agreement between the two primary readers was 70% for 672 aged fish. Age-frequency analysis of the hook-and-line samples (Figure 3) determined that age distribution of spotted bass was similar between non-wadeable and wadeable streams (Kruskal-Wallis test, $X^2 = 11.1$, df = 1, $P = 0.001$). Age-frequency was also different between electrofishing and angling samples in non-wadeable streams (Kruskal-Wallis test, $X^2 = 44.0$, df = 1, $P < 0.001$). The rate of sexual maturation was similar for spotted bass from wadeable streams

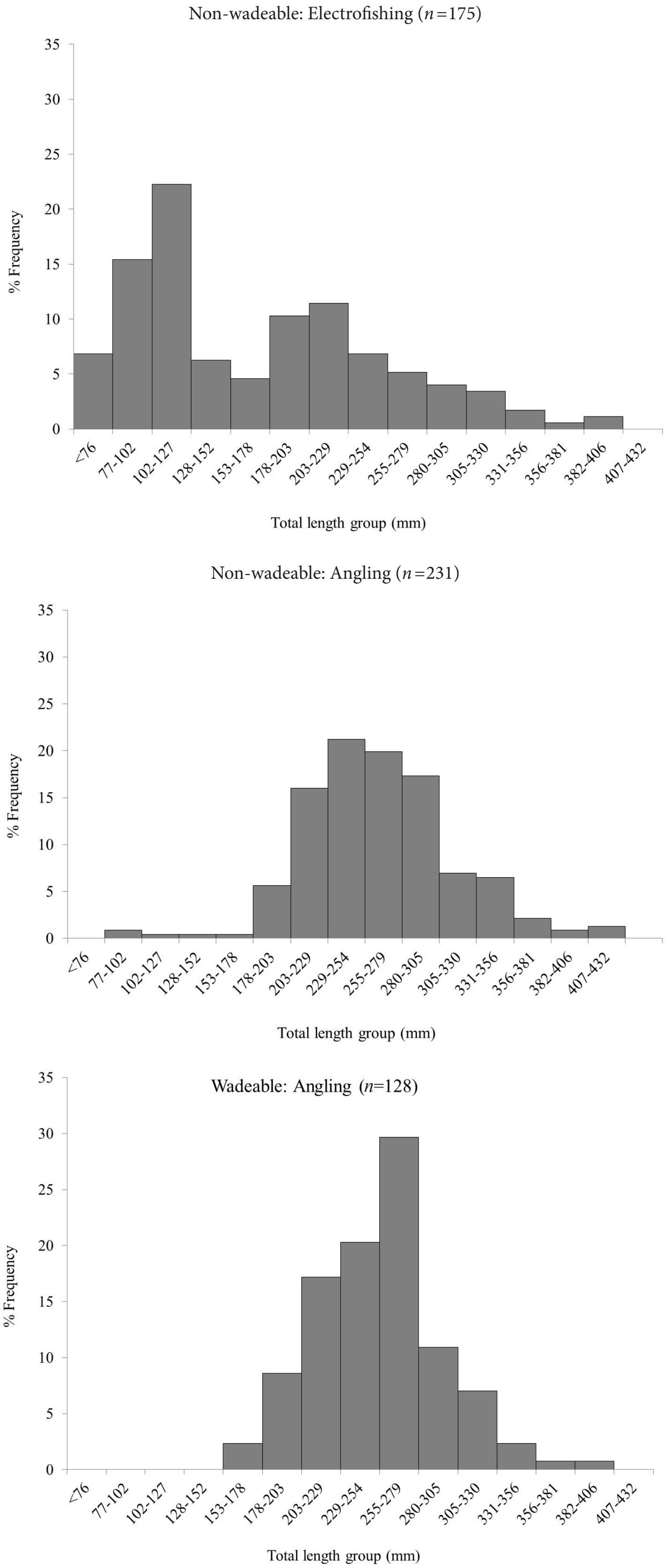

Figure 2. Length-frequency histograms (25-mm groups) of spotted bass sampled by (a) boat-mounted electrofishing ($n = 175$) and (b) angling ($n = 231$) gears in non-wadeable streams and by (c) angling in wadeable streams ($n = 128$) draining the Lake Pontchartrain Basin of Mississippi and Louisiana (2009–2012).

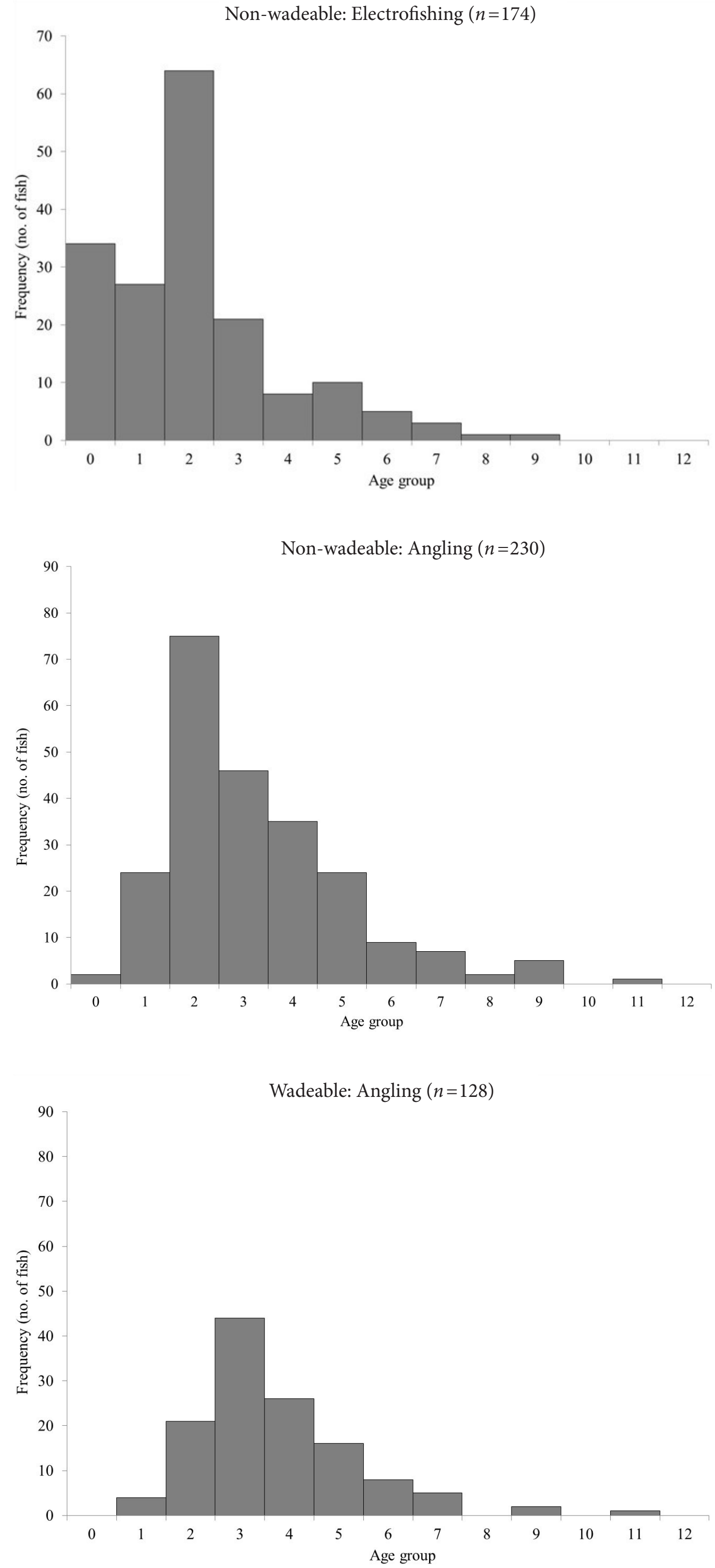

Figure 3. Age-frequency histograms of spotted bass sampled in non-wadeable streams by (a) boat-mounted electrofishing ($n = 174$) and (b) angling gears ($n = 230$) and in (c) wadeable streams by angling ($n = 128$) in the Lake Pontchartrain Basin of Mississippi and Louisiana (2009–2012).

Table 1. A comparison of proportional stock density (PSD) indices and size-specific mean relative weights of spotted bass populations sampled by hook-and-line angling in two stream types draining the Lake Pontchartrain Basin in Louisiana and Mississippi during 2009–2012. Size categories were those presented by Neumann et al. (2012). Numbers in parentheses are the upper and lower 95% confidence limits.

	Non-wadeable ($n = 498$)	Wadeable ($n = 174$)
Size structure indices (95% CI)		
PSD	23 (18–27)	24 (17–32)
PSD-P	4 (2–6)	2 (0–5)
Mean relative weight		
Sub-stock	89	85
Stock	90	85
Quality	91	87
Preferred	94	82

($n = 92$) and non-wadeable streams ($n = 184$). The LM50 value estimated by logistic regression models was 195 mm TL for non-wadeable streams ($F = 380.3$, $P < 0.001$, adj. $R^2 = 0.61$) and 202 mm TL for wadeable stream fish ($F = 80.8$, $P < 0.001$, Adj. $R^2 = 0.59$).

Stomachs were removed and diet composition assessed from 266 and 174 fish from non-wadeable and wadeable streams, respectively. Food was found in 54% of spotted bass from non-wadeable streams ($n = 266$) and in 55% of fish from wadeable streams ($n = 174$). From these stomachs, 351 prey items were recovered. Size-specific diet compositions were similar between stream types (Table 2). Fishes, crayfishes, and aquatic insects were the dominant prey types consumed for all size groups numerically comprising 77% of the diet of non-wadeable stream fish (Table 2) and 69% of the diet of wadeable stream fish (Table 2). Sum-F tests indicated that percent composition was not significantly different with respect to stream type ($F = 1.0$, $P = 0.29$). However, fish diets were different with respect to fish size ($F = 34.0$, $P < 0.001$). In general, larger-sized spotted bass consumed more crayfish and fish, other vertebrates, and multiple types of aquatic and terrestrial insects ($F > 4.0$, $P < 0.05$). Percent occurrence of diet items was significantly different between streams ($F = 24.7$, $P = 0.001$). Individual F-tests suggested that crayfish ($F = 9.2$, $P = 0.001$) and fish ($F = 5.2$, $P = 0.001$) were consumed more frequently in wadeable streams than in non-wadeable streams (see Table 2). In addition, percent occurrence of diet items was different among fish size groups, following the same pattern as that for percent composition.

The crayfish taxa consumed were either *Orconectes* spp. or *Cambarus* spp. Gomphidae dragonfly nymphs were the dominant aquatic insect consumed, followed by Megaloptera larvae and mayfly nymphs (*Caenis* spp.). A wide variety of fishes were consumed, including blacktail shiner (*Cyprinella venusta*), blackspotted topminnow (*Fundulus olivaceus*), western mosquitofish (*Gambusia affinis*), dusky darter (*Percina sciera*), longnose shiner (*Notropis longisrostris*), threadfin shad (*Dorosoma petenense*), largemouth bass (*Micropterus salmoides*), sunfish (*Lepomis* spp), and unidenti-

Table 2. Percent composition by number and percent occurrence of diet items found in 271 spotted bass within four size groups (<101, 101–200, 200–300, and 301–406 mm TL) from stomachs that contained food. Fish were collected from non-wadeable and wadeable streams draining the Lake Pontchartrain Basin during 2009-2012.

	Non-wadeable ($n = 266$)				Wadeable ($n = 174$)			
Diet category	**<101**	**101–200**	**200–300**	**301–406**	**<101**	**101–200**	**201–300**	**301–406**
% composition								
Aquatic insect	14.3	42.3	16.4	11.1	0.0	0.0	11.1	0.0
Crayfish	14.3	12.5	28.1	48.1	0.0	25.0	52.4	45.5
Fish	0.0	27.9	21.1	29.6	40.0	25.0	11.1	18.2
Grass shrimp	14.3	0.0	0.0	0.0	20.0	0.0	0.0	0.0
Other vertebrate	0.0	0.0	2.3	7.4	0.0	0.0	6.3	0.0
Plant	0.0	0.0	4.7	0.0	0.0	12.5	7.9	9.1
Other invertebrate	14.3	4.8	6.3	3.7	0.0	0.0	1.6	0.0
Other insect	42.9	12.5	21.1	0.0	40.0	37.5	9.5	27.3
% occurrence								
Aquatic insect	16.7	19.6	13.8	14.3	0.0	0.0	10.3	0.0
Crayfish	16.7	23.2	32.1	42.9	0.0	25.0	56.9	50.0
Fish	0.0	44.6	22.9	33.3	40.0	25.0	12.1	25.0
Grass shrimp	16.7	0.0	0.0	0.0	20.0	0.0	0.0	0.0
Other vertebrate	0.0	0.0	2.8	9.5	0.0	0.0	6.9	0.0
Plant	0.0	0.0	5.5	0.0	0.0	12.5	6.9	12.5
Other invertebrate	16.7	8.9	7.3	4.8	0.0	0.0	1.7	0.0
Other insect	33.3	19.6	24.8	0.0	40.0	37.5	10.3	37.5

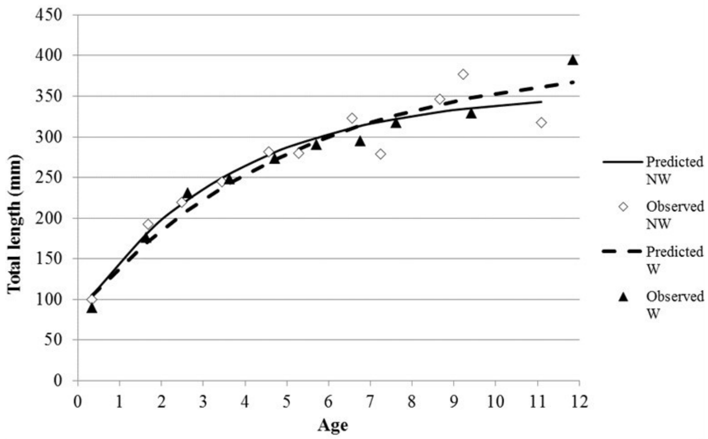

Figure 4. Observed mean lengths at age of spotted bass sampled in non-wadeable streams ($n = 498$ fish) and in wadeable streams ($n = 174$ fish) draining the Lake Pontchartrain Basin of Mississippi and Louisiana (2009–2012). Predicted lengths at age (lines) derived from von Bertalanffy growth curves are also presented. For non-wadeable stream fish, von Bertalanffy growth parameter estimates were $L_{inf} = 355.9$, $k = 0.27$, and $t_0 = -0.93$. For wadeable stream fish, growth parameter estimates were $L_{inf} = 399.4$, $k = 0.19$, and $t_0 = -1.24$.

fied darters (*Etheostoma* spp.). Unusual prey items found were a 275-mm long water snake (*Nerodia* spp.), a juvenile rabbit (probably *Sylvilagus aquaticus*), and an 87-mm long lizard (*Anolis* spp.).

The von Bertalanffy growth curves of spotted bass were similar between stream types (Figure 4). However, the maximum theoretical length of fish from non-wadeable streams was smaller ($L_{inf} = 356$ mm) than that for fish from wadeable streams ($L_{inf} = 399$ mm). Subsequently, the k parameter for non-wadeable stream fish ($k = 0.27$) was larger than that for wadeable stream fish ($k = 0.19$), and wadeable stream fish reached a larger average maximum size. Mean length-at-age and slopes of length-age regressions were similar between stream types, suggesting that spotted bass from non-wadeable streams grow at a similar rate as those from wadeable streams (ANCOVA, Global model $F = 103.2$, $P < 0.001$, stream type * age interaction $F = 0.6$, $P = 0.45$). The main effect of stream type was not significant ($F = 0.05$, $P = 0.83$). Similarly, weighted catch-curve regressions indicated that estimated total annual mortality (A) was low but nearly equal for populations from non-wadeable streams (A = 16%, $F = 39.3$, $P < 0.001$, $R^2 = 0.87$) and wadeable streams (A = 17%, F = 25.3, $P < 0.001$, $R^2 = 0.74$).

Discussion

Population structure and diet of spotted bass in Louisiana streams were generally similar between non-wadeable and wadeable streams in the LPB, indicating that populations within a river basin may be able to respond similarly to management actions (e.g., length and creel limits). However, our results suggest differences between free-flowing rivers and impounded river populations in other regions. Eggleton et al. (2012) reported a mean PSD of 38 (range 21–56) and a mean PSD-P of 10 (range 0–19) in nine navigation pools on the regulated Arkansas River. The PSD values reported for spotted bass from other studies of free-flowing systems are comparable to our PSD values (23 and 24 for non-wadeable and wadeable streams, respectively). In Eleven Point River, PSD averaged 23, and in an Oklahoma population it was 16 (Johnson et al. 2009).

Other free-flowing stream populations of spotted bass have shown similar or even greater body condition. For example, spotted bass mean W_r was 93, 103, and 101 in Eleven Point River in Arkansas, Kansas streams, and Virginia streams, respectively (Johnson et al. 2009). These condition values are similar to those from non-wadeable stream spotted bass from our study, but higher than the values from wadeable stream fish. As stream size increases longitudinally along a continuum, available energy (g m^{-2}) increases for fish that may achieve larger body size (e.g., omnivores, planktivores, and piscivores) according to the river continuum concept (Vannote et al. 1980). Thus, it makes sense for spotted bass in larger non-wadeable streams to achieve greater body condition than those from smaller, wadeable streams. During our study period, water levels were adequate and were not considered unusually low or high, so our W_r estimates likely reflected the typical condition of spotted bass in LPB wadeable and non-wadeable streams.

Spotted bass diets from Eleven Point River, Arkansas, were most similar to those from our study, having consumed primarily crayfish (60%), followed by fish (48%), and insects (4%). The primary fish species eaten in Eleven Point River were rheophilic cyprinids, such as river chub (*Nocomis micropogon*) and bigeye chub (*Hybopsis amblops*) (Johnson et al. 2009). It appears that diets from free-flowing stream populations rely less heavily on fish for energy than in impounded populations. Similar to our results, aquatic insects have been reported to make up a moderate composition and occurrence in spotted bass diets from streams, following that of fish and crayfish. But other studies have found that even the largest fish sampled consume aquatic insects in streams and rivers (Vogele 1975). Regardless of river regulation type (i.e., impounded or free-flowing), spotted bass are limited energetically, probably as a result of their greater consumption of insects and crayfish (Vogele 1975). Moreover, stream-dwelling spotted bass diet patterns are likely a function of habitat preferences of the for structurally heterogeneous (e.g., pools with large woody debris adjacent to current) and diverse environments (e.g., daily/seasonal flow variation) they experience in streams (Horton and Guy 2003) relative to impoundments. This likely allows for a more opportunistic foraging strategy than that for lakes and impounded rivers.

We found that as fish size increases, the reliance on fish and crayfish increases, although insects and other arthropod invertebrates are still consumed by large fish (> 305 mm TL). Vogele (1975) reported the same pattern in studies of stream dwelling spotted bass from Illinois, Indiana, Kansas, and Ohio. Even though ontogenetic diet changes occur in spotted bass, with fish becoming more important, crayfish and insects still make up an important component of the diet as fish grow. Interestingly, we found that fish were a relatively large part the diet of small spotted bass (100–200 mm TL, 27.9% composition by number, 44.6% frequency of occurrence). Similarly, in a study by Ryan et al. (1970) from the Tchefuncte River, Louisiana, spotted bass < 125 mm TL fed primarily on fish (33% by volume), followed by insects (12%), whereas spotted bass 150–370 mm TL consumed mostly crayfish (37%), followed by fish (18%), and insects (17%). In coastal plain streams, it appears that spotted bass take advantage of the caloric benefit that fish prey provide early on in their life, perhaps as a mechanism for coping with the more variable environment that occurs in free-flowing streams relative to impoundments. However, in impoundments, spotted bass have been found to opportunistically switch to alternate prey as fish resources declined (Vogele 1975).

Growth rate tends to be greater in impounded populations of spotted bass than those from free-flowing streams (Vogele 1975). Eggleton et al. (2012) reported maximum theoretical lengths of spotted bass was 351–429 mm TL from nine navigation pools in the Arkansas River. In our study, spotted bass growth was much slower, reaching 305 mm TL in 8.1 and 8.8 years in non-wadeable and wadeable streams, respectively. However, it must be noted that spotted bass in Arkansas River navigation pools face a more lentic environment than populations from free-flowing rivers. Differences in growth rate between impoundments and free-flowing streams is likely caused by a difference in diet, with fish of greater caloric value being consumed in impoundments (e.g., shad) and proportionately more crayfish and other invertebrates (i.e., lower caloric content) being consumed in free-flowing streams. Based on reported back-transformed mean-length-ate age of other populations (Carlander 1977), spotted bass growth rate in LPB streams, regardless of stream size, is at the mid-point between midwestern U.S. streams (slowest growth) and southeastern U.S. reservoirs (fastest growth).

Total annual mortality (A) estimates from regulated rivers are reportedly greater than the wadeable (A = 17%) and non-wadeable (A = 16%) stream populations in our study. In the Arkansas River, total annual mortality estimated from catch curves was 43%–57% across nine navigation pools sampled by night time boat electrofishing (Eggleton et al. 2012). In the Flint and Ocmulgee rivers, Georgia, Sammons and Goclowski (2012) reported that total annual mortality of spotted bass ranged between 48%–59% in the Flint River and was 54% for the Ocmulgee River population. Fishing pressure for spotted bass may be higher in larger systems compared to those in our study, leading to higher total annual mortality. However, it should be noted that mortality estimates from our angling data are likely to be lower than other estimates calculated from boat electrofishing samples, due to inherent size/age selection of the gear types.

In summary, spotted bass population structure and diet were generally similar between free-flowing non-wadeable and wadeable streams in the Lake Pontchartrain Basin. Spotted bass from wadeable streams ate crayfish and fish more frequently compared to non-wadeable streams, but spotted bass from both stream types relied on a diet of arthropods, while feeding opportunistically on fish and other vertebrates when available. This reliance on arthropod food items may have limited growth of spotted bass (Glover et al. 2013). Future research should be conducted on region-specific black bass populations in rivers and streams to identify population structure and management implications for these warmwater stream fisheries at multiple spatial scales within the stream networks. Many of the habitats in the streams in this project were difficult to sample using conventional gears as non-wadeable reaches were too large for typical shallow-water gear (i.e., backpack electrofishing, seines) while wadeable reaches were inaccessible to boat electrofishing in gear. Angling proved to be an important tool to collect numbers and sizes of fish in this study. Although wadeable and non-wadeable stream populations of spotted bass were similar with respect to size structure, growth, and mortality, there appears to be no reason why populations should be managed differently as a result of stream size or position in a river basin. However, it seems apparent that spotted bass from free-flowing stream reaches, regardless of channel size, should be managed differently from populations that occur in impoundments.

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