Angler Catch and Harvest of Targeted Sportfishes in Small Georgia Lakes

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Abstract: Public fishing areas (PFAs) in Georgia are intensively managed freshwater impoundments that provide a variety of fishing opportunities to anglers. Management efforts and fishing regulations at these PFAs depend on understanding basic aspects of recreational fishing pressure, catch, and harvest. Accordingly, we conducted a roving creel survey during January–December 2013 at Marben PFA in middle Georgia to quantify sport fishing total effort, catch, harvest, and fish catch by species, number, and weight in 14 lakes. Almost all of the anglers interviewed (84% of the 1159 parties) targeted a preferred species; of these anglers, 34.7% targeted a second species, and 5.7% targeted a third species. Sunfish (*Lepomis* spp.) ranked highest among primary, secondary, and tertiary targeted species, whereas channel catfish (*Ictalurus punctatus*) was the highest ranked quaternary targeted species. Largemouth bass (*Micropterus salmoides*) ranked second among primary, tertiary, and quaternary targeted species. Catches and harvest of targeted sportfish in Marben PFA varied considerably by species. Sunfish were the most abundant species by number caught (37 fish ha^{-1}) and harvested (19 fish ha^{-1}; 2.25 kg^{-1}) for the entire survey period. Black crappie (*Pomoxis nigromaculatus*) had the lowest reported catch (2.03 ha^{-1}) and second lowest observed harvest 0.50 kg ha^{-1}), but largemouth bass had the lowest observed harvest in number (0.42 ha^{-1}) and observed weight (0.41 kg ha^{-1}). Rankings of species targeted by Marben anglers differed from those of other Georgia anglers, who targeted largemouth bass most, followed by sunfish and channel catfish. These findings imply that Georgia PFA fishery managers may give consideration to site-specific management objectives when developing or managing local fisheries rather than relying on state summary statistics. The smaller profile and intensive management of the Marben PFA impoundments benefited anglers of varying skill levels and backgrounds equally, making it an ideal setting for recruiting new anglers while still challenging experienced anglers.

Key words: creel surveys, sunfish, largemouth bass, black crappie, catch and release

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Recreational fishing is both a culturally and economically important outdoor activity in Georgia. Based on the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 764,000 Georgia anglers fished 8.5 million angler-days and spent US$729 million on trip-related expenses to fish Georgia waters (USDI et al. 2011). While both freshwater and saltwater angling opportunities are available in Georgia, most anglers in 2011 (~92%) participated in freshwater fisheries because of the abundant freshwater angling opportunities throughout the state. In addition to the many large reservoirs, rivers, watershed lakes, and privately-owned ponds that constitute Georgia's warmwater fisheries, public fishing areas (PFAs) in Georgia are intensively managed freshwater impoundments that provide excellent fishing opportunities to anglers seeking a variety of recreational fishing experiences. The fisheries section of Georgia Department of Natural Resources Wildlife Resources Division (GADNR-WRD) currently manages 10 PFAs throughout the state. This study focuses specifically on anglers fishing the impoundments that comprise the Marben PFA in Mansfield, Georgia.

Management of recreational fisheries involves supervision and regulation of the three major components that define a fishery: aquatic habitat, fish populations, and the angling population (Murphy and Willis 1996). Managers often implement creel surveys to collect information from anglers regarding their angling activity to gain a better understanding of this component of the fishery. Creel surveys are used frequently to understand the use and human dimensions of fisheries, and information derived from creel surveys is directly useful in guiding management actions pertaining to fishing regulations, stocking efforts, habitat enhancement, and angler education programs (Pollock et al. 1994, Knuth and McMul-

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lin 1996). Conducting a creel survey involves interviewing anglers and provides the opportunity to not only obtain data relevant to angling activity but also to gain insight on angler preferences and attitudes towards current management strategies and regulations (Pollock et al. 1994, Malvestuto 1996).

To evaluate the efficacy of current management efforts and fishing regulations at Marben PFA, managers need to understand the basic aspects of recreational fishing activity, including fishing effort, catch, and harvest. Additionally, with a goal of improving or optimizing the anglers' fishing experience, understanding what characteristics of the fishery influence angler satisfaction with fishery quality is also important for evaluating current management practices and garnering public support for management decisions (Fisher 1997). Information gathered from angler interviews aids managers in identifying aspects of the fishery that may need attention, including fishery characteristics that are not directly concerned with the water bodies (e.g., accessibility to fishing sites, operating hours, and angler crowding). Because angling success is often determined by estimating and comparing variables related to catch or harvest (Colvin 2000, Hickman 2000, Bailey 2007), we examined angler total catch, release, and fish harvest to evaluate sport fishing success. The goal of this study was to quantify and evaluate fishing activity and angler success on the PFA to inform local fisheries management. Our specific objectives were to: 1) quantify sport fishing effort, post-catch activity (catch and release), and fish catch by species, number, and weight in 14 Marben PFA lakes, 2) determine preferred species for individual anglers to better understand the angling community at Marben PFA, and 3) use creel survey results to develop potential alternatives for future sportfish management at Marben PFA.

Methods

Study Site

Marben PFA is a multiple-lake fishery located within the larger Charlie Elliot Wildlife Center (CEWC) complex in Mansfield, Georgia. Detailed descriptions of this PFA are given in Roop et al. (2018). Briefly, the PFA has 14 small ponds (0.4 ha) and lakes (<40 ha) totaling 112 ha of water that provide anglers with the opportunity to catch a variety of species. Popular species targeted at the PFA include largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), channel catfish (*Ictalurus punctatus*), and bluegill (*Lepomis machrochirus*) and redear sunfish (*L. microlophus*); hereafter collectively referred to as sunfish (GADNR-WRD 2013). All of the above-mentioned species occur in most ponds; however, a subset of small ponds did not have black crappie and one pond contained only catfish and bream. All ponds are managed with a 356-mm minimum length limit and five fish daily limit for largemouth bass, a 30-fish limit for black crappie, a 15-fish limit for sunfish, and a five fish limit for catfish. All ponds receive annual applications of fertilizer and liming to improve productivity, stocking of forage species (e.g., threadfin shad [*Dorosoma petenense*] and gizzard shad [*D. cepedianum*]), and habitat enhancements like fish attractors and weed control.

Field Procedures

Traditional creel methods (e.g., access point interviews) do not work well in places like Marben PFA, with its mosaic of small impoundments across a complex spatial structure and multiple entrances that make traditional methods to survey and monitor fishing activity difficult (Roop et al. 2018). Therefore, a roving creel survey (Pollock et al. 1994) was conducted from 23 January 2013 to 29 December 2013. Non-uniform probability sampling (Cochran 1977, Pollock et al. 1994) was used to allocate sampling probabilities, based on observed fishing effort, to weekend and weekday and among three 6-h time blocks within each day (six strata). During each sampling event, a starting point (one of six lakes) and direction of travel (north or south) were randomly selected by rolling a die and flipping a coin, respectively. A predetermined route was followed from lake to lake, and all anglers were approached in the order that they were first encountered. A jon boat was used to access anglers fishing by boat or fishing from the bank in areas difficult to access on foot. Information recorded by the creel clerk included total time spent fishing, fishing method, rank of all targeted species, number of anglers in the fishing party, total number and weight of each species harvested, and total number and approximate length (inches) of each species released. The total number of each species harvested was weighed (g). At the temporal midpoint of each survey period, the creel clerk ceased interviews and roved by vehicle throughout the fishery once to obtain an instantaneous (<30 min) count of anglers. Once the instantaneous count was completed, interviews resumed until the end of the sampling period. Individual surveys generally lasted about 5–10 min.

Estimation Procedures (Creel Data)

Estimates of total monthly fishing effort, catch, and harvest were calculated from the aggregation of partial-day observations based on incomplete fishing trips (Pollock et al. 1994). Briefly, daily estimates of catch-per-unit effort (CPUE, harvest-per-unit effort (HPUE), or weight harvested per-unit effort (WPUE) were calculated using the R_2 (mean-of-ratios) equation:

$$R_2 = \sum_{i=1}^{n} (c_i / L_i)/n$$

Where, i denotes an angler, n is the number of anglers interviewed, c_i is the catch of ith angler, and L_i is the fishing duration (h) of the ith angler (Pollock et al. 1994). Angler interviews that had a fishing time of less than 0.5 h were removed from analysis to avoid biasing variances of the mean-of-ratio estimator (Pollock et al. 1997). Estimates of effort ($\hat{E}$) were calculated by the equation:

$$\hat{E} = \sum_{i=1}^{n} (I_i \times T)/\pi_i$$

Where, n is the number of sampling periods, I_i is the instantaneous count of anglers, T is the length of the secondary sampling unit (i.e., time blocks with a day; SSU) sampled, and π_i is the corresponding sampling probability of the SSU. Estimated effort ($\hat{E}$) was reported in angler h. Daily estimates of total catch, harvest, and weight harvested were a product of estimated effort ($\hat{E}$) and the daily catch or harvest rate (in terms of number of fish or weight). Variances of $\hat{E}$ were calculated between primary sampling units (weekday vs weekend; PSU) and then combined using the following equations:

$$\hat{Var}(\bar{e}_i) = s_i^2/n_i,$$
$$\hat{Var}(\hat{E}_i), = N_i^2 \times \hat{Var}(\bar{e}_i),$$
$$\hat{Var}(\hat{E}) = \hat{Var}(\hat{E}_1) + \hat{Var}(\hat{E}_2),$$
and
$$S\hat{E}(\hat{E}) = \sqrt{\hat{Var}(\hat{E})}$$

Where s_i^2 is the squared standard deviation of the monthly effort estimates from the ith PSU, n_i is the number of counts taken in the ith PSU, and N is the number of available fishing days in the ith PSU. Variances of catch, harvest, and weight harvested were calculated similarly.

Results

During the survey, 103 on-site roving surveys were completed. The response rate for the creel survey was 97% (1159 of 1195 fishing parties participated). Almost all of the anglers interviewed (84%) sought a preferred species; of these anglers, 34.7% targeted a second species, and 5.7% targeted a third species. Sunfish was the most commonly targeted species listed as primary, secondary, and tertiary species; whereas, channel catfish was the highest ranked quaternary targeted species. Largemouth bass ranked second among primary, tertiary, and quaternary target species. Sixteen percent of anglers targeted "anything." Anglers used a wide variety of bait types, often employing two methods simultaneously to target different fish species (e.g., using cut bait for channel catfish while using live bait for sunfish). Thus, ascertaining the primary fishing method was difficult in many cases. Sixty percent of anglers used some form of live bait (e.g., a variety of worms, crickets, live minnows, or small sunfish), and 30% of anglers used artificial lures. Anglers who fished with lures typically targeted largemouth bass or black crappie. Seven percent of anglers used cut bait to target catfish. A few anglers trolled or used "Other" methods such as fly rods to target sunfish and grass carp (*Ctenopharyngodon idella*).

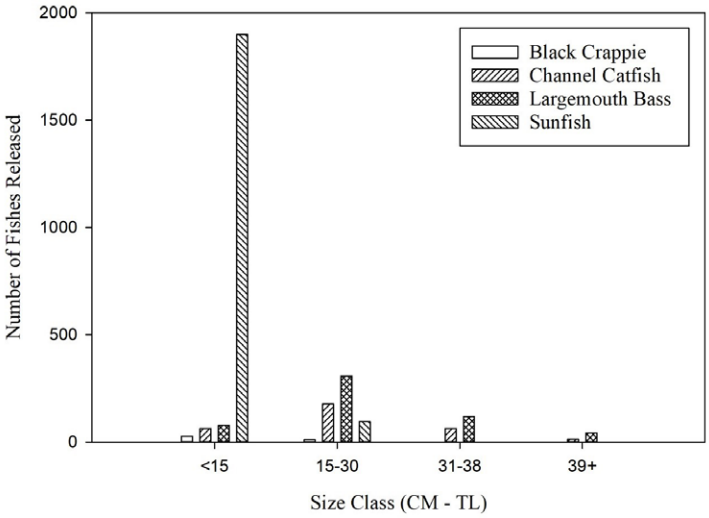

Figure 1. Numbers of selected sportfishes of various sizes released by anglers fishing at Marben Public Fishing Area (near Mansfield, Georgia) during January–December 2013.

Reported catches and observed harvest of targeted sportfish in Marben PFA varied considerably by species. Sunfish were the most abundant species by number and weight of fish caught (37 ha^{-1}) and harvested (19 ha^{1}; 2.25 kg ha^{-1}) for the entire survey period. Ninety-five percent of the sunfish released were less than 15 cm in length (Figure 1). Black crappie had the lowest reported catch (2.03 ha^{-1}) and observed harvest (0.50 kg ha^{-1}), while largemouth bass had the lowest observed harvest in number (0.42 ha^{-1}) and observed weight (0.41 ha^{-1}). Relatively similar numbers of largemouth bass (5.19 ha^{-1}) and channel catfish (5.34 ha^{-1}) were caught over the survey period.

During the study period, estimated total fishing effort was 6.03 angler h ha^{-1}. Estimated mean monthly fishing effort was seasonably variable and ranged from 11.62 angler h ha^{-1} in December to 195.14 angler h ha^{-1} in May (Table 1); the annual mean monthly effort was 7523 angler h mo^{-1} (SD = 5956). Directed effort varied substantially among species, and sunfish and largemouth bass anglers comprised most (58%) of the fishing effort (Table 1). Total fishing effort over the 12-month period was 808 angler h ha^{-1}. Average monthly fishing pressure was 67.17 angler h ha^{-1} (SD = 53) with a low of 11.62 angler h ha^{-1} in December and a high of 195.14 angler h ha^{-1} in May. Greater than 70% of the total daily effort was expended on four lakes: Bennett, Margery, Fox, and Dairy.

Table 1. Monthly directed effort estimates (Ê; angler h ha^{-1}) and SE for anglers targeting largemouth bass (LMB), black crappie (BLC), sunfish, channel catfish (CCF), and "Anything" (anything as target species) at Marben PFA near Mansfield, Georgia, during 2013.

	LMB		BLC		Sunfish		CCF		"Anything"		
Month	**Ê**	**SE**	**Ê**	**SE**	**Ê**	**SE**	**Ê**	**SE**	**Ê**	**SE**	**All**
January	9.81	0.96	9.34	2.88	0.00	0.00	0.00	0.00	0.00	0.00	19.15
February	7.44	0.60	4.99	2.55	1.96	1.61	0.64	0.64	2.35	0.95	13.38
March	13.93	2.35	34.48	5.00	16.04	6.64	2.84	1.52	13.42	5.24	80.70
April	23.14	5.91	22.32	5.97	31.29	5.14	6.00	1.55	9.19	3.29	91.94
May	38.13	14.05	34.00	25.90	72.93	14.74	7.84	3.26	42.24	7.62	195.14
June	31.18	6.12	7.40	2.88	40.05	9.98	13.63	4.02	32.08	9.02	124.33
July	19.96	3.93	2.15	1.09	33.25	8.70	10.89	1.59	12.37	2.11	78.63
August	21.80	7.10	2.00	1.23	24.93	6.55	5.18	2.37	10.59	3.63	64.50
September	13.53	3.44	2.57	1.61	23.22	4.16	7.69	3.25	12.72	3.24	59.73
October	11.72	2.37	3.80	1.24	16.77	4.44	2.05	1.10	2.66	0.97	37
November	3.98	1.41	14.78	4.13	5.15	2.13	0.12	0.12	1.88	1.07	25.91
December	3.18	1.64	5.89	1.99	2.21	1.64	0.31	0.31	0.05	0.05	11.62
Total	197.80		143.69		267.80		57.19		139.55		806.03

However, these lakes are relatively large, so standardizing effort by lake size revealed that the highest density of effort (>100 angler h ha^{-1}) occurred on smaller ponds of ~1–3 ha where relatively moderate fishing effort occurred.

Estimated mean monthly catch among all lakes was 90.75 fish mo^{-1} (SD = 80.86) and ranged from a low of 3.84 fish mo^{-1} in January to a high of 254.61 fish mo^{-1} in May; the annual total was 1,089 fish mo^{-1}. The mean monthly estimate of total number of fish harvested was 41.33 fish mo^{-1} (SD = 34.12) and ranged from a low of 0.57 fish mo^{-1} in January to high of 106.41 fish mo^{-1} in May; the annual total was 495 fish mo^{-1}. The monthly mean weight of fish harvested was 7.29 kg mo^{-1} SD = 5.98) and ranged from a low of 1.02 kg mo^{-1} in November to a high of 20.15 kg mo^{-1} in May and totaled 87.58 kg mo^{-1} of fish harvested during 2013 (Table 2).

Monthly catch compositions revealed that sunfish dominated total catch (78%) and harvest (83%) at Marben PFA throughout the year (Figures 2 and 3). On average, sunfish comprised approximately 66% of fish catch mo^{-1} (SD = 27%) and 73% of fish harvested mo^{-1} (SD = 28%). Black crappie were caught less frequently than any other species and accounted for only 5% of overall catch (Figure 2) and 9% of harvested fish (Figure 3). Channel catfish accounted for 6% of total catch and 7% of total harvest; mean monthly catch was 6% (SD = 5%) and mean monthly harvest was 8% (SD = 8%). Largemouth bass accounted for 12% of total estimated catch but only 1% of total harvest and, on average, repre-

Table 2. Mean monthly estimates and standard errors of total catch (Ĉ; *n* fish ha^{-1}), harvest (Ĥ; *n* fish ha^{-1}), and weight (Ŵ; kg ha^{-1}) on 13 lakes at Marben Public Fishing Area (Mansfield, Georgia) during 2013.

Month	**Ĉ**	**SE (Ĉ)**	**Ĥ**	**SE (Ĥ)**	**Ŵ**	**SE (Ŵ)**
January	3.84	2.19	0.57[a]	†	1.58	†
February	7.38	0.46	4.35	1.02	1.69	0.40
March	101.92	26.17	68.94	17.64	14.83	3.71
April	126.25	17.87	55.48	2.33	9.15	1.01
May	254.61	99.37	106.41	62.57	20.15	16.85
June	198.06	56.41	70.16	13.15	11.93	2.16
July	125.13	21.41	52.39	11.92	6.68	1.33
August	104.79	30.33	48.82	17.78	7.37	2.73
September	108.90	24.35	59.74	21.32	7.67	2.23
October	40.07	7.13	20.83	5.58	2.82	0.74
November	11.96	5.86	4.80	2.55	1.02	0.54
December	6.19	5.12	3.42	2.83	2.71	2.11
Totals	1089.10		4629.00		87.58	

† Standard error was not calculated because of insufficient replication.
a. Harvest estimate based solely on harvest of two largemouth bass.

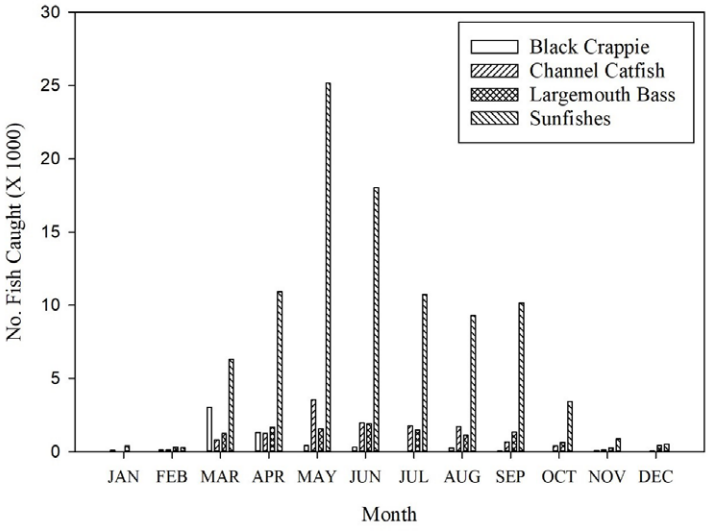

Figure 2. Estimated total monthly catch of selected sportfishes by anglers at Marben PFA near Mansfield, Georgia, during 2013.

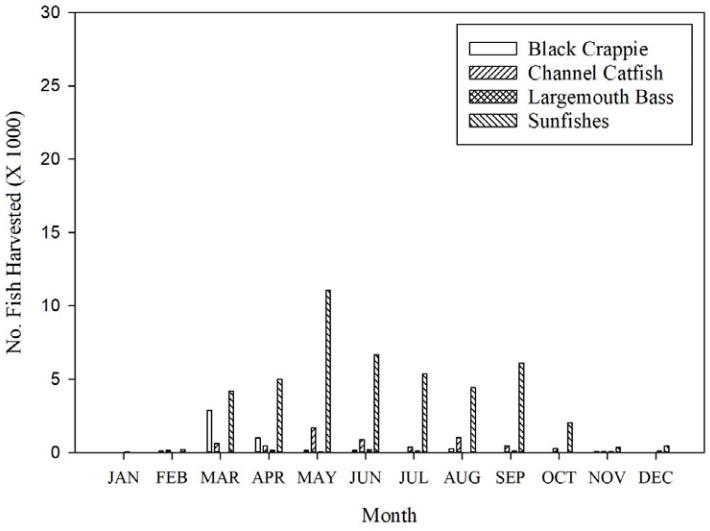

Figure 3. Estimated total monthly harvest of selected sportfishes by anglers at Marben PFA near Mansfield, Georgia, during 2013.

sented 22% of monthly catch (SD = 26%) and 10% of monthly harvest (SD = 27%).

Discussion

Sunfishes were clearly the most popular sportfish species among anglers fishing at Marben PFA, both as primary and supplementary target species. Preference of primary targeted species by anglers at Marben PFA differed from that of Georgia anglers statewide who targeted largemouth bass, followed by sunfish, channel catfish, and black crappie, and "anything" (USDI et al. 2011). Largemouth bass ranked second among primary, tertiary, and quaternary target species targeted at Marben PFA. Hence, the anglers at this PFA represented a sunfish-oriented group, where sunfish and largemouth bass exchanged roles as the primary target species among most anglers. These findings imply that Georgia PFA fishery managers should give additional consideration to local management objectives when developing or managing fisheries. Specifically, angler groups that may be regionally or demographically differentiated may express fishing preferences that deviate from statewide summary statistics. In this case, Marben PFA anglers may appreciate a management approach that emphasizes quality sunfish stocks while also maintaining high catch rates for largemouth bass. For example, using supplemental feeders for sunfish stocks while maintaining high densities of largemouth bass through restrictive harvest regulations would produce preferable fishing opportunities for most of the Marben PFA angling community.

Based on comparisons of results from other creel surveys conducted on similar fisheries, fishing pressure at Marben PFA was substantial, but not excessively high. For example, Chizinski et al. (2014) reported a total fishing effort of approximately 340 angler h ha^{-1} during a 7-month survey of anglers on 20 small lakes in Nebraska. Similar studies on small state-owned fisheries reported annual fishing pressures ranging from 340 to 1538 h ha^{-1} on five Oklahoma impoundments (Jarman et al. 1967), as high as 2636 h ha^{-1} for some Alabama lakes (Powell 1975), and an average of 741 to 1167 h ha^{-1} for small impoundments in Missouri (Rassmussen and Michaelson 1974). Fishing pressures have varied substantially among Georgia PFAs as well, ranging from 320 h ha^{-1} to 923 h ha^{-1} 1993 (K. Weaver, GADNR-WRD, personal communication). Therefore, fishing pressure at Marben PFA during our study appeared to be moderate compared to other regional small impoundments, but relatively high among PFAs in Georgia.

Total harvest estimates suggested that fish populations at Marben PFA were being harvested at intermediate levels. Sunfishes constituted most of the estimated fish harvest (409 fish ha^{1}; 50.8 kg ha^{-1}) throughout the year. Mature and routinely fertilized ponds should yield approximately 1605 fish ha^{-1} or 174 kg ha^{-1} of sunfish on an annual basis (Lewis 1998). Natural resource agencies in southeastern states recommend average annual bluegill harvest rates ranging from 91 to 116 fish ha^{-1} (64 to 69 kg ha^{-1}) for small unfertilized impoundments (Dauwalter and Jackson 2005). Because Marben impoundments were routinely fertilized and limed, they should produce more biomass of sunfish per ha than unfertilized impoundments. Therefore, although sunfish harvest at Marben PFA was relatively high compared to other sportfish species, overharvest was likely not a concern. Harvest of black crappie and channel catfish was relatively low. Black crappie harvest is typically variable from year-to-year within a fishery because their popu-

lations naturally experience large fluctuations in density and size structure (Miranda and Allen 2000, Pine et al. 2001). Considering the low estimated catch and harvest of black crappie during the study, Marben PFA lakes may have contained low black crappie densities that would be reflective of a "cyclical" population in its low phase. However, if black crappie populations seem stable and angling success for crappies in Marben lakes remains low, there is a potential for overcrowding, which could potentially lead to stunting (Baumhoer and Kelly 2016). Concurrently monitoring black crappie populations and angler harvest could help managers understand whether angler harvest rates of black crappie reflect fluctuating population trends or stunted populations.

Largemouth bass harvest was relatively low throughout the year, well below the recommended annual harvest rates of 55 fish ha^{-1} or 15 to 20.6 kg ha^{-1} for small unfertilized impoundments (Dauwalter and Jackson 2005). The low occurrence of largemouth bass harvest at Marben PFA is consistent with the growing popularity of catch-and-release fishing among largemouth bass anglers that has been observed nationwide over the past half century (Allen et al. 2008, Myers et al. 2008, Isermann et al. 2013). Low angler harvest of largemouth bass may leave sufficient stocks to regulate black crappie populations via predation and interspecific competition for food resources (Boxrucker 1987). Considering the popularity of largemouth bass on this fishery, their low harvest rate, and the high harvest rate among black crappie anglers, management objectives could prioritize maintaining quality-sized largemouth bass stocks over preventing high black crappie densities because angler exploitation and LMB predation should naturally manage the latter.

Conclusions

The fishery profile developed for Marben PFA highlights the utility of small, intensely managed state-owned impoundments for providing quality fishing opportunities. This fishery supports a group of diverse anglers from highly specialized largemouth bass anglers to the occasional angler targeting "anything." The Marben PFA withstands substantial spring fishing pressure and moderate fishing pressure throughout the rest of the year. Anglers obtained consistent catches for most species throughout the survey, although sunfish generally dominated catch and harvest compositions. Largemouth bass angling was mainly for sport at this fishery, and the low harvest-oriented anglers may have been seeking opportunities to catch trophy largemouth bass.

Future studies at Marben PFA could focus on describing the relationship between black crappie population abundance and their harvest by anglers, which would potentially address the relatively low observed catch and harvest of black crappie throughout most of the survey. Investigating the lake-specific size structure of sunfish populations may also explain the relatively high release rates of sunfish that were observed throughout the study. If sunfish populations were skewed heavily towards smaller, younger individuals, further management may be required to restructure those populations. Sunfish populations may be successfully restructured through supplemental feeding (Berger 1982) or by increasing predator abundance (Schneider and Lockwood 2002). Generally, restructuring sunfish populations through culling is not a practical long-term management strategy (Schneider and Lockwood 2002). Considering the popularity of sunfishes and largemouth bass among Marben PFA anglers, developing a diverse array of opportunities for anglers to catch sunfish and largemouth bass (e.g., creating "trophy" ponds) would likely be well-received by Marben anglers. Similar strategies may be equally successful at providing quality fishing opportunities at small intensively management fisheries to a diverse group of anglers throughout the region.

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