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Potential influence of male nesting levels on Largemouth Bass *Micropterus salmoides* populations

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Abstract - Spring population estimates combined with complete nest counts of Largemouth Bass were conducted on two small north-temperate lakes to determine what portion of the spawning male population is potentially affected by angling. Spring population estimates of Largemouth Bass were made from 2007 to 2011. Populations ranged from 512 to 727 on Burgen Lake and 297 to 432 on Union Lake. A census of nesting males was made in each lake from 2008 to 2011. Timing of nest construction was also recorded each year. Overall, a small percentage of male Largemouth Bass in either lake constructed nests in any given year (3.8% to 23.6%). In most years the protected season, designed to reduce or eliminate harvest of nesting male bass, did little to protect fish which were often actively providing parental care to eggs or larvae when the season opened. The small percent of males nesting could make them, and the population as a whole, vulnerable to the effects of catch and release as well as catch and keep angling.

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INTRODUCTION

Largemouth Bass *Micropterus salmoides* are the most popular sport fish in North America, and 5th among Minnesota anglers (USFWS 2014). Due to their popularity among anglers, research directed at evaluating traditional management strategies as well as investigations regarding the long and short-term effects of increased angling pressure on Largemouth Bass populations are needed (Claussen 2015).

Similar to other centrarchids, male Largemouth Bass provide sole parental care to their eggs and offspring. When water temperatures approach 16°C, male Largemouth Bass begin excavating bowl-like nests by fanning away organic and other particulate matter and exposing a firm substrate (Heidinger 1975). Specific habitats preferred by nesting male Largemouth Bass in north-temperate lakes ranges from coarse-woody habitat to emergent vegetation (Reed and Pereira 2009; Lawson et al. 2011; Weis and Sass 2011). Following a brief courtship, female Largemouth Bass deposit eggs in the excavation where the attending male immediately fertilizes them. Protection of the eggs, larvae, free-swimming fry, and eventually fingerlings can last up to six weeks and survival of these life stages is largely dependent on the ability of the male to provide this level of care (Cooke et al. 2007). Moreover, vigilance and duration of parental care is directly related to brood survival (Parkos et al. 2011). This substantial and often aggressive investment in care also makes males quite vulnerable to angling (Suski and Philipp 2004). Removal of the parental male via angling from the nest can result in variable levels of brood loss up to and including total loss, as well as an increased likelihood of complete nest abandonment (Philipp et al. 1997; Suski and Philipp 2004). Furthermore, the physiological costs to males, which are removed but subsequently released, can directly limit the ability of the male to provide the level of care and defense needed by the brood for survival (Philipp et al. 1997; Cooke et al. 2002). Evidence strongly suggests therefore that year-class formation and eventual recruitment to the fishery may be dependent on the ability of males to provide adequate care for the duration of these vulnerable life stages. Furthermore, angling of nesting bass has been demonstrated to reduce nest-site fidelity thereby influencing nesting location (Twardek 2017). Consequently, traditional management of the species, particularly in more northern regions of North America, has included seasonal closures during spawning season (Quinn 2002).

In addition to the more immediate effects angling may have on nesting male Largemouth Bass, recent studies have provided significant insight into the potential, long-term effects of angling on bass populations. As previously noted, the aggressive nature of a male guarding a nest also makes them vulnerable to angling (Suski and Philipp 2004). This behavior has led to the hypothesis that angling can produce fisheries-induced evolution (FEI), a concept previously limited to marine species/stocks. Under this hypothesis, anglers, by removing the most aggressive males from nests can drive down population-level reproductive success and as a result, annual declines in recruitment (Philipp et al. 2015). Admittedly a working proposal, and likely context-driven (Sutter et al. 2012), the authors provide substantive evidence that angling affects male bass and resulting decreases in parental care in fished populations is a net detriment to reproductive fitness (Philipp et al. 2015). Consequently, long-term sustainability of Largemouth Bass populations may depend on conservative management strategies that protect vulnerable males.

Due to the vulnerabilities of individual fish and the possibility of affecting Largemouth Bass at the population level, this study was undertaken to determine what portion of the spawning male population is potentially affected by angling. Specifically, the objectives were to 1) determine the population size of males of two Largemouth Bass populations, 2) determine the number of males constructing nests from each population in a given year and 3) monitor nesting chronology and phenology. Finally, based on the results of these objectives various management scenarios are critiqued.

METHODS

Study Lakes

Largemouth Bass populations in Burgen and Union Lakes, both located in Douglas County, near the City of Alexandria, Minnesota were subjects of this study. Burgen Lake is 70 ha (19 littoral ha) with a maximum depth of 14.6 m. Spring (May to mid-June) Secchi disk readings ranged from 2.5 to 4 m. Union Lake is 43 ha (23 littoral ha) and also has a maximum depth of 14.6 m. Water clarity during the spring, as measured by a Secchi disk ranged from 3.9 to 5.8 m. Both lakes are moderately productive and the majority of shoreline on both lakes has been residentially developed. Centrarchids, mainly Bluegill *Lepomis macrochirus,* Black Crappie *Pomoxis nigromaculatus,* Pumpkinseed *L. gibbosus,* along with Largemouth Bass compose the bulk of the fish community, although both lakes also contain fishable populations of Northern Pike *Esox lucius* and Walleye *Sander vitreus*. Yellow Perch *Perca flavescens* are present in both lakes while the presence of Cisco *Coregonus artedi* is limited to Burgen Lake.

Population Estimates

Largemouth Bass were collected with a combination of daytime and nighttime electrofishing from 2007 to 2012 during April and May. Each lake was sampled a minimum of 6 times in each year. In all cases the entire shoreline was sampled, and on occasion areas with concentrations of fish were targeted to bolster numbers of both tagged fish and recaptures. Sampling ceased prior to Largemouth Bass spawning and the open season for angling. All Largemouth Bass were collected, measured to the nearest mm (TL) and those $\geq$ 180 mm tagged with a passive integrated transponder (PIT) tag. Tags were inserted from the posterior of the pelvic girdle internally such that tags sat anterior within the girdle structure. Fish were allowed to fully recover from electrofishing and tagging before being released near the capture site.

Spring abundance of Largemouth Bass in both lakes was determined annually from 2007 to 2011 using the Chapman modification of the Schnabel method. Recaptures were treated as Poisson variables for the calculation of confidence intervals (Ricker 1975; Shroyer et al. 2003). Because male Largemouth Bass approximating 180 mm in Burgen Lake were known to construct nests (author, unpublished data), and to ensure the majority of males that could potentially build nests were accounted for, estimates included fish exceeding that length. The ratio of males to females in both populations across all years was assumed to be 1:1 and was based on a large sample of Largemouth Bass collected over multiple years from across Minnesota that were examined for sex and maturity (McInerny 2014). Regression analysis was used to examine if a relationship between the number of nesting males and the male population as a whole, existed. To accomplish this, populations from both lakes were combined over the four years that both nest counts were done, and population estimates were made.

Nest Counts and Phenology/Chronology

Each year, from 2008 to 2011, as water temperatures approached 14°C searches for nests occurred daily on both lakes. Searches continued until no new nests were observed on two consecutive days. Due to the exceptional water clarity searches were done from a boat with a raised platform and powered by an electric trolling motor. On most occasions nests were visible in water up to 3.3 m deep. For each search event an attempt was made to survey the entire shoreline. However, when weather events such as wind or cloud cover limited the ability to see the lake bottom, lee shores were searched, or the search was cancelled. Although the search followed the shoreline, searches extended out from shore until the depth exceeded 3.5 m. Searches began shortly after dawn and continued throughout the day.

When a nest was found its location was noted with a GPS unit as well as drawn on a map to eliminate duplicate nests. Substrate type, distance to shore, and distance to in-lake habitat (e.g., coarse woody habitat or hardstem bulrush *Scirpus sp.*) was noted, as was the depth of the water. Distance to other nests was also estimated and calculated from GPS points at a later date. Only active nests were included in this study; nests were considered active when the male had been observed on the nest during three consecutive nest days or if the presence of eggs was visually observed. Nest activity was monitored at each visit through mid-June or until the male had either abandoned the nest or fry had dispersed. The date each nest appeared was noted and reported as day of year (DOY). Using a submersible wand, each nesting male was also scanned for the presence of a PIT tag.

The amount of preferred nesting habitat was also determined for each lake. This was accomplished by mapping the features previously identified by Reed and Pereira (2009) as preferred nesting habitat, including water less than 3.5 m but greater than 0.3 m in depth, hard substrate, and the presence of previous year's growth of emergent or submerged vegetation. These estimates were completed in 2007 and again in 2011. Active nests found in these areas were considered to be located within preferred habitat.

RESULTS

Spring population estimates of Largemouth Bass 180 mm and longer in Burgen Lake ranged from a high of 727 in 2009 to a low of 512 in 2011, or 40 and 28 per littoral ha respectively (Table 1). Union Lake estimates ranged from 432 in 2009 to 297 in 2011 or 19 and 12 per littoral ha, respectively (Table 1). Estimates of males in the population, assuming a 1:1 ratio, therefore ranged from a high of 363 in Burgen Lake in 2009 to a low of 149 in Union Lake in 2011.

Nests counted on Union Lake ranged from a high of 40 in 2010 to a low of 19 in 2008, representing 24 and 10.3% of the male population, respectively (Table 2). On Burgen Lake, active nests ranged from a high of 27 in 2010 to a low of 22 in 2011, representing 8.5% of the males in the population in both years (Table 2). No significant relationship was found between the number of nesting male bass and the number of males in the population ($r^2 = 0.04$).

In all years, nest construction began on the same day in both lakes. Active nests appeared as early as DOY 126 in 2010 and as late as DOY 155 in 2008 (Table 3). Median DOY for active nests was 141.

The estimated amount of preferred spawning habitat did not change between 2007 and 2011 on either lake. On Burgen Lake the amount of preferred habitat was estimated at 9 ha while 17 ha were designated as preferred habitat on Union Lake, representing 13 and 24%, respectively, of the area of each lake (Table 2). A low of 74 to a high of 93% of nests were located in this habitat.

TABLE 1. Spring population estimates, including 95% confidence intervals, the number of males estimated in each population and the number of males per littoral hectare of Burgen (B) and Union (U) Lakes, Minnesota. Estimates were made using the Chapman modification of the Schnabel method.

Year (Lake)	Population Estimate	95% CI	Males (N)	Males/littoral ha
2007 (B)	525	386-693	263	29.1
2007 (U)	315	272-441	158	13.7
2008 (B)	649	512-831	330	36.3
2008 (U)	370	343-436	185	16.0
2009 (B)	727	589-879	364	40.2
2009 (U)	432	358-518	216	18.8
2010 (B)	634	464-811	317	35.0
2010 (U)	338	288-392	169	14.7
2011 (B)	512	409-634	259	28.0
2011 (U)	297	245-351	149	12.9

TABLE 2. Number of active nests observed (2008 through 2011), percent population of males nesting (lower 95% CI), and number of active nests found in preferred nesting habitat (%, PH) on Burgen (B) and Union (U) Lakes, Minnesota.

Year (Lake)	# Nests	% Males Nesting (lower 95% CI)	Nests in PH (%)
2008(B)	25	7.5(4.8)	23 (93)
2008(U)	19	10.3(5.5)	14 (74)
2009(B)	14	3.8(2.3)	12 (86)
2009(U)	30	13.3(8.3)	29 (90)
2010(B)	27	8.5(5.8)	22 (81)
2010(U)	40	23.6(13.8)	33 (83)
2011(B)	22	8.5(5.3)	22 (77)
2011(U)	18	12.8(7.3)	14 (78)

TABLE 3. First date (day of year) of observing active nests on Burgen and Union Lakes, Minnesota, 2007 to 2011, and the opening date of the recreational fishing season for black bass in Minnesota.

Year	Active Nest Observation	Opening of Bass Angling
2007	137	146
2008	155	145
2009	142	143
2010	126	149
2011	146	148

DISCUSSION

Based on the estimated springtime abundance of Largemouth Bass in both lakes it appears that in most years a relatively small proportion of the male bass in either population constructs nests. While it is likely that active nests were missed in the current study, based on the exceptional water clarity and small size of both lakes that number is likely minimal. Furthermore, nest searches conducted by an independent group of researchers, using both boat observations and snorkeling on Union Lake in 2014 and 2015 found 26 and 36 nests, respectively; while 81 nests were found in 2013, a number considerably higher than any previous searches of the lake, independent of researcher or method (Loppnow 2017). Reed and Pereira (2009) also found similar numbers of nests in Burgen Lake in 2000 (n = 28). Nest numbers in this study were found to be similar to those found in small Ontario lakes (Philipp et al. 2015) but considerably lower than that found in two small northern Wisconsin lakes (Weis and Sass 2011). Even in the unlikely event that half the nests within either of the lakes had been missed, the percent of males in the population constructing nests would not have exceeded 50% in any year in either lake on one occasion.

It is also possible that variability within the population estimates may have both under and overestimated the number of males within the population actively nesting in a given year. To account for that possibility, it is first helpful to consider the lower 95% C.I. for each population in each year. This conservative approach would likely be useful for examining any management strategies designed to protect actively nesting male Largemouth Bass. Still, when working from this approach, only once would the percent of males constructing nest have exceeded 25%: 27.7% on Union Lake in 2010. Furthermore, population estimates on both lakes, particularly when compared on a per hectare basis, were found to be very similar to other estimates of Largemouth Bass populations in Minnesota. During their evaluation of special regulations, Shroyer et al. (2003) found densities ranging from 7.8 to 37.1 fish per ha in four lakes that are quite similar in size and depth but slightly more productive than either Burgen or Union lakes. It is worth noting that they also used the Chapman modification of the Schnabel estimation method. Even when taking into account the variability associated with the population estimates, as well as taking into account the possibility of missed nests, it is still apparent that a small proportion of males in either population construct nests in any given year. Therefore, populations in small lakes such as these may be vulnerable, both to catch and release and catch and keep angling during the spawning season. Immediate threats include increased predation on eggs and larvae due to males being removed from their nests and increased physiological stress which can result in nest abandonment as well as a reduced ability to protect eggs and young (Cooke et al. 2002), increased human-induced nest-site selection (Twardek et al. 2017), as well potential long-term effects of FEI (Philipp et al. 2015). The effects on these populations may also be magnified in north-temperate lakes where Largemouth Bass are often more aggressive in defending their nests and are also limited to one spawning event per year (Sutter et al. 2014). As an example, Philipp et al. (2015) reported that up to 86% of nesting bass in seasonally exploited lakes hit a lure. If this rate were to be applied to the nesting males on Burgen and Union lakes and combined with 100% nest abandonment (Cooke et al. 2002) as few as 2 nests would be remaining in any given year. Granted, this may be considered a worst-case scenario, but the demonstrated vulnerability of these fish calls for conservative approaches to protection, particularly in lakes where recruitment may be low or where preferred nesting habitat is declining. In lakes with adequate to abundant recruitment as well as abundant spawning habitat, managers can be more liberal in allowing for angling opportunities and harvest. This would be particularly true in lakes where populations are expanding into new waters, becoming more abundant due to climate and habitat change, or a combination of those factors (Hansen et al. 2017; Bethke and Schmalz 2020). In instances where recruitment is high and could be affecting growth, managers could use angling to reduce recruitment and improve growth rates (Lopnow 2017).

Originally designed to protect nesting males, the effectiveness of a closed season with an opening date in late May is questionable, as in most years males will be well into construction and protection when they are first subjected to angling pressure. Monitoring the nesting chronology of these populations demonstrated that Minnesota's closed season (at the time of this study, angling for black bass closed until the Saturday prior to Memorial Day when harvest was then allowed) on black bass angling provided minimal protection to nesting males in either population over the course of the study[1]. Nesting males were protected under the closed season in 2007 and 2010 because nesting began nine to 23 days before the season opened. Largemouth Bass eggs can hatch within 5 days and fry may begin dispersing 3 to 5 days after hatching (Becker 1983; Scott and Crossman 1973). Therefore, full protection of nests would at a minimum require 8 days post spawn. The average date of nest construction on both lakes occurred on DOY 141 whereas the average opening of fishing for black bass in the state was day 146, 5 days after nesting had commenced. In late springs, which occurred in 2008, there was no protection for nesting Largemouth Bass. Should further population monitoring of these and other Largemouth Bass populations indicate that recruitment is declining or if further research should lend insight into FEI on similar populations, managers should consider more conservative management strategies such as extended closed seasons to protect nesting male bass. These strategies could be more important on small lakes, particularly on those with limited preferred spawning habitat.

Largemouth Bass are also dependent on specific habitats for nesting and nest success (Wagner et al. 2006; Reed and Pereira 2009; Lawson et al. 2011). Similar to other Minnesota populations, males nesting on Burgen, and Union lakes demonstrated a strong affinity for hardstem bulrush and/or coarse woody habitat and firm, sandy substrates (Reed and Pereira 2009). The strong preference for specific habitat and the resulting density of nests, combined with clear water makes nesting males even more vulnerable to anglers who can readily find and target nesting males. In these situations, disproportionally high catch rates during the spawning season can occur (Gwinn and Allen 2010). As a consequence, nest success is likely to decrease, nest abandonment likely to increase or nests are constructed in less than suitable habitat (Twardek et al. 2017). Habitat preservation or enhancement on small, clear lakes should be considered critical for maintaining sustainable Largemouth Bass populations.

[1] It should be noted that since the completion of field study for this research, Minnesota regulations now allow for catch and release angling for black bass two weeks prior to the harvest season.

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