CONTRIBUTION OF STOCKED WALLEYE IN LAKE HIWASSEE

Federal Aid in Sport Fish Restoration
Project F-108
Report Type: Final Report

A. Powell Wheeler
and
Amanda M. Bushon

Fisheries Biologists

North Carolina Wildlife Resources Commission
Division of Inland Fisheries
Raleigh

2018

Keywords: Hiwassee, Walleye, gill net, stocking evaluation

This project was funded under the Federal Aid in Sport Fish Restoration Program utilizing state fishing license money and federal grant funds derived from federal excise taxes on fishing tackle and other fishing related expenditures. Funds from the Sport Fish Restoration Program are used for fisheries management and research, aquatic education, and boating access facilities. The program is administered cooperatively by the N.C. Wildlife Resources Commission and the U.S. Fish and Wildlife Service.

Abstract.—The Walleye *Sander vitreus* population in Lake Hiwassee, North Carolina has been supported with hatchery-raised oxytetracycline (OTC)-marked fingerlings since 2004. Bushon et al. (2009) verified that the stocked fingerlings were recruiting to age-1; however, no research has verified recruitment to older ages or examined their contribution to the overall population. In 2015 and 2016, we collected Walleye bycatch from Striped Bass *Morone saxatilis* gill-net surveys, aged them, and verified hatchery origin by checking their otoliths for OTC marks. We collected 109 Walleye over the two study years and assigned ages to 107. OTC-marked Walleye were found throughout most year-classes (2004–2015). Stocked Walleye comprised 58.3 and 47.5% of the catch from the 2015 and 2016 samples and in both cases significantly (P < 0.0001) exceeded our success criteria of 25.0%. Natural recruitment still contributes to the Walleye population, but only occasionally from years of successful recruitment. In contrast, the stocked fingerlings are consistently recruiting every year. The Walleye fingerling stocking in Lake Hiwassee continues to be a successful management strategy.

Lake Hiwassee is a moderate-sized (2,477 ha), moderate elevation (465 m above mean sea level), oligotrophic, hydropower reservoir on the Hiwassee River in Cherokee County, North Carolina (TVA 1954; NCDWQ 2005). The origin of Lake Hiwassee's Walleye *Sander vitreus* population is unknown. Although initial Walleye stocking records exist for many other North Carolina Wildlife Resources Commission (NCWRC) District-9 reservoirs (*i.e.*, Glenville, Nantahala, Fontana, Chatuge, and Santeetlah), there are no records for Lake Hiwassee. Paulk and Borowa (1986) noted the Walleye fishery in Lake Hiwassee was present since it's impoundment in 1940; this suggests the population could be native. However, Bushon et al. (2009) believed they were stocked before 1957.

Regardless of the origin, natural reproduction sustained the Lake Hiwassee Walleye population until 1999 when Blueback Herring *Alosa aestivalis* invaded the reservoir. From 1999 to 2002, Walleye recruitment declined by 59% annually (Wheeler et al. 2004a). Although the mechanism by which Blueback Herring reduce Walleye recruitment is unknown, Wheeler et al. (2004b) found fish eggs, mostly from White Bass *Morone chrysops*, in Blueback Herring diets and suggested that ovivory during spring spawning periods may have contributed to the decline.

From 2004 until 2006, the NCWRC conducted an experimental annual stocking of 30,000 oxytetracycline (OTC)-marked fingerling Walleye into Lake Hiwassee to compensate for poor natural recruitment. Bushon et al. (2009) studied the recruitment of these Walleye to age-1 and found that the stocked Walleye contributed 52, 56, and 77% to the 2005, 2006, and 2007 year-classes. The success of this experiment led to Lake Hiwassee being managed with continued Walleye stocking; however, the recruitment of stocked Walleye to ages ≥2 and the overall contribution to the Walleye population has not been evaluated.

The objective of this study is to determine if the annual fingerling Walleye stockings are recruiting to ages ≥2 and making a substantial (≥25%) contribution to the overall population.

Methods

Since 2004, we have followed the methods in Bushon et al. (2009) and continued annual stockings of 30,000 OTC-marked fingerling Walleye in Lake Hiwassee. Besler (2004) and Bushon et al. (2009) found 30 d OTC mark retention using these methods was ≥99%. This stocking rate (12.1/ha) is similar to other North Carolina reservoirs (NCWRC 2018).

We used gill-net surveys in November of 2015 and 2016 to sample the Striped Bass population (Wheeler and Bushon 2018) and used the Walleye bycatch for this study. Twelve sites were selected throughout the reservoir to avoid gill net hazards (*e.g.*, submerged trees and docks) and located where we believed we could capture Striped Bass (*i.e.*, relatively shallow submarine ridgelines adjacent to deeper water). We fished three single panel gill nets (3.0 x 61.0-m) of four bar mesh sizes (50.8, 63.5, 76.2, and 101.6 mm). Each year, the 12 gill nets were randomly assigned to the 12 sampling sites (Figure 1) and fished perpendicular to the shore for a 24-h period. The Walleye were bagged by site, placed on ice, transported to the lab where they were measured for total length (TL; mm), weighed (g), and sexed within 24 h. In addition, we removed sagittal otoliths for age determination and mark detection.

Walleye ages were estimated by counting otolith annuli with a compound microscope. Two readers independently examined each otolith. If the otoliths were ≤age-1, they were aged intact (without breaking or sectioning); whereas, older otoliths were aged after removing two 0.5-mm sections of the focus using a Buehler Isomet low-speed diamond wheel saw. Ages were assigned after the readers discussed and resolved disagreements.

After aging, the otoliths were checked for OTC marks under a compound microscope with transmitted epiflourescent light. Sectioned otoliths were placed on a glass microscope slide and examined on both sides of the two, 0.5-mm sections. Intact otoliths were attached to microscope slides with cyanoacrylate glue and ground with 800-grit sandpaper, before exposing them to epiflourescent light.

We calculated Walleye relative weight according to Murphy et al. (1990). The percentage of stocked Walleye in our samples was used as an estimate of the percentage of stocked Walleye in the entire reservoir. Similar to Bushon et al. (2009), we considered the fingerling stockings a success if they contributed 25% to the overall Walleye population. We used the exact binomial test to evaluate the null hypothesis that the percentage of stocked Walleye in the reservoir =25% against the alternative hypothesis that the percentage was >25%. The tests were considered significant at an α of 0.05. In addition, The Clopper and Pearson (1934) method estimated 95% confidence intervals for the percent of stocked Walleye in the reservoir. All statistical procedures were performed in R (version 3.4.3).

Results

We collected 109 Walleye during this investigation from 24 net-nights of effort (Table 1) and assigned ages and year-classes to 107. Walleye recruited to our gill nets at age-1 and we did not collect any age-0. The Walleye in our sample were relatively large (mean TL = 520 mm) and relatively old (mean age = 6.2 years) and concentrated in older (2008–2010) year-classes (Figure 2). This Walleye sample may be biased towards larger fish because we used gill net mesh sizes and techniques intended for Striped Bass.

The year-classes represented in our samples ranged from 2004 to 2015, and no Walleye were collected from year-classes that pre-dated (≤2003) our stocking. In the 2015 sample, 58.3% of the Walleye collected were identified as stocked by the presence of OTC marks which was significantly higher ($P < 0.0001$) than the null hypothesis of 25.0%. The 95% confidence interval for the percentage of stocked Walleye in the reservoir in 2015 ranged from 43.2 to 72.4% (Table 1). The 2016 sample produced similar results and found OTC marks on 47.5% of the Walleye which was also significantly higher ($P < 0.0001$) than 25.0%. The 95% confidence interval for the percentage of stocked Walleye in the reservoir in 2016 ranged from 39.1 to 65.7% (Table 1).

Discussion

Overall, we found an OTC mark on 52.3% of the Walleye collected in both years combined. Thus, fingerling Walleye stocking is an effective management strategy and makes a substantial contribution to the adult Walleye population in Lake Hiwassee.

Our sampling also discovered that nearly half of the Walleye we collected were unmarked. The unmarked Walleye primarily occur in the 2008–2010 year-classes; whereas, the OTC-marked Walleye are distributed more evenly across all year-classes (Figure 2). Although the use of Striped Bass gillnetting techniques may have targeted older year-classes, 2008–2010 was likely an exceptional period for Walleye natural reproduction and recruitment. For example, in 2016 the unmarked Walleye from these three year-classes were nearly half (47.5%) of all the Walleye collected, although they were relatively old (6–8 years) and there were 11 years classes represented in the sample. In contrast to the apparent erratic pulses of natural recruitment, the stocked Walleye are recruiting consistently to all year-classes and likely stabilizing the Walleye population across years.

Management Recommendations

1.) Continue annual stocking of OTC-marked fingerling Walleye in Lake Hiwassee.

2.) Sample Lake Hiwassee with typical Walleye gill nets to better assess the population age and size structure.

Acknowledgements

This research was a collaborative effort and would not be possible without the support of many members of the Inland Fisheries Division. Specifically, we appreciate the annual efforts of the District-8 Fisheries Management staff who collect the Walleye broodfish and the Table Rock State Fish Hatchery staff who spawn, rear, mark, and stock the fingerlings. The edits and suggestions of D. Goodfred and S. Loftis improved this report.

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TABLE 1.—Catch per unit effort (CPUE; individuals/net night), total length range (TL; mm), relative weight (W_r), and percent stocked for Walleye collected during this study. Standard deviations are reported for CPUE and W_r and a 95% confidence interval is reported for percent stocked.

Year	N	CPUE	TL range	W_r	Percent stocked
2015	49	4.1 (6.7)	428–650	95.5 (9.4)	58.3 (43.2–72.4)
2016	60	5.0 (8.3)	437–623	91.2 (9.5)	47.5 (39.1–65.7)

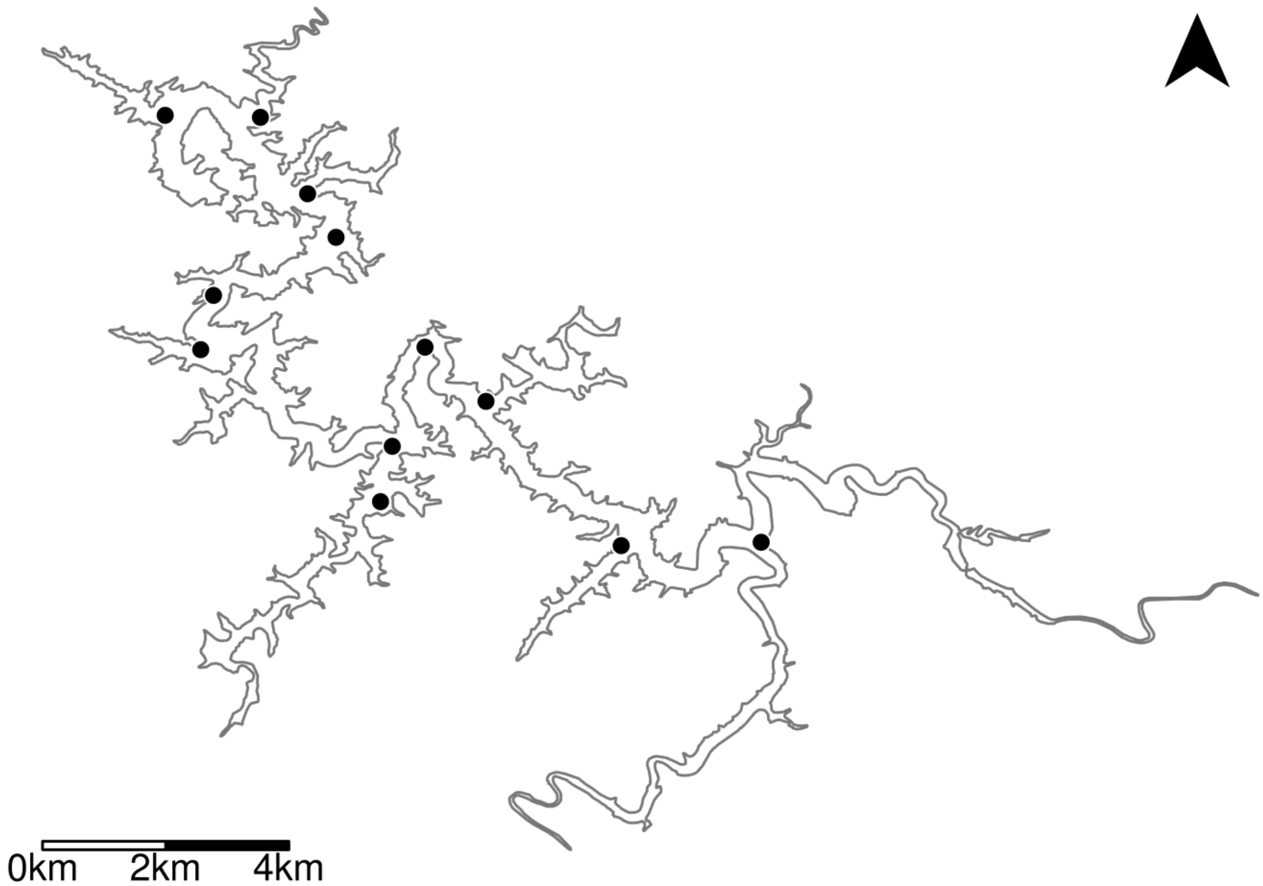

FIGURE 1.—Map of Lake Hiwassee, Cherokee County, North Carolina. The dots show the 12 gill net locations used in this study (2015–2016).

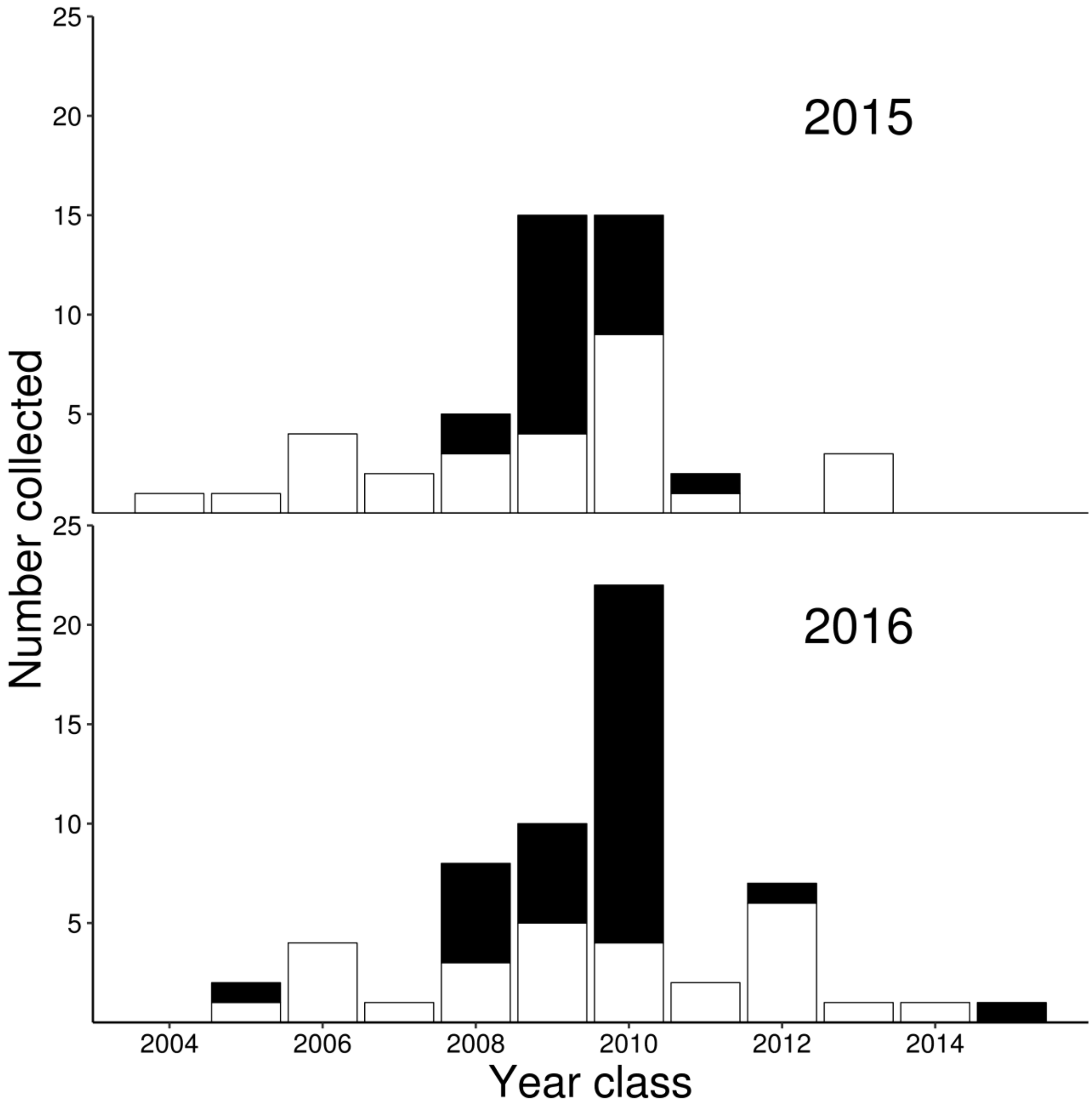

FIGURE 2.—The frequency distribution of Walleye year-classes collected from 2015 and 2016 during this study. All Walleye were from OTC-marked year-classes and checked for OTC marks. White shading represents OTC-marked Walleye and black shading represents unmarked Walleye.