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Evaluation of anal fin spines, otoliths, and scales for estimating age and back-calculated lengths of yellow perch in southern Green Bay

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ABSTRACT

Southern Green Bay supports important fisheries for yellow perch *Perca flavescens* and valid estimates of age structure and growth are critical to effective management. Anal fin spines and scales are used by the Wisconsin Department of Natural Resources for age estimation, but these structures may provide lower precision and accuracy than otoliths. The primary objective of our assessment was to determine if age estimates, among-reader precision, and mean back-calculated total lengths (TLs) at age differed among scales, anal fin spines, and otoliths. Ages estimated from anal fin spines were more precise than scale ages, were as precise as otolith-based ages, and generally agreed with consensus ages estimated from sectioned otoliths. Relationships between TL and radii of calcified structures were linear for scales, anal spines, and otoliths along two different transects. Mean back-calculated TLs were generally similar between intercept-corrected direct proportion (ICDP) and linear regression (LR) models, but otolith-based direct proportion models (no intercept correction) generally provided higher back-calculated mean TLs at ages 1 and 2 than ICDP and LR models. Mean back-calculated TLs at age estimated from whole otoliths were higher than estimates for other structures; but differences among anal fin spines, scales, and sectioned otoliths were <10 mm. Our results suggest biologists have little to gain by switching to otoliths when assessing age structure and growth for this fast-growing yellow perch population with relatively few fish ≥age 6, but additional analyses are warranted for slower-growing perch populations in the Great Lakes where older fish are more common.

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Introduction

Yellow perch *Perca flavescens* support economically important sport and commercial fisheries across much of their range, including the Great Lakes (Beard Jr. and Kampa, 1999; Isermann et al., 2005; Vandergoot et al., 2008), and understanding population dynamics and demographics are critical to effectively managing these high-profile fisheries (Isermann et al., 2007; Radomski, 2003; Schneeberger, 2000). Describing key population attributes such as age structure, mortality, and growth requires estimation of yellow perch ages from calcified structures.

Historically, ages of yellow perch collected from the Great Lakes were estimated using scales (Danehy et al., 1991; Hile and Jobes, 1941), but numerous studies have demonstrated that scale ages can be inaccurate (Heidinger and Clodfelter, 1987; Ross et al., 2005) and imprecise (Hammers and Miranda, 1991; Kocovsky and Carline, 2000; Robillard and Marsden, 1996). Otoliths have routinely been shown to provide more accurate (Erickson, 1983; Heidinger and Clodfelter, 1987; Ross et al., 2005) and precise (Boxrucker, 1986; Isermann et al., 2003; Vandergoot et al., 2008) age estimates than scales. Robillard and Marsden (1996) recommended the use of otoliths, rather than scales, for estimating the age of yellow perch >150 mm total length (TL) in Lake Michigan because of higher precision and detection of more annuli. However, removal of otoliths requires fish sacrifice which may not be desirable in certain situations. Furthermore, previous percid assessments have often used cracked or sectioned otoliths for age estimation (Kocovsky and Carline, 2000; Niewinski and Ferreri, 1999; Vandergoot et al., 2008), and these preparation techniques can increase the time required to obtain age estimates for a sample of fish (Isermann et al., 2003). Use of whole otoliths for yellow perch age estimation could reduce processing times (Isermann et al., 2003) and the need for specialized equipment used for sectioning, but only two previous studies reported using this approach for estimating ages of yellow perch (e.g., Blackwell and Kaufman, 2012; Maceina and Sammons, 2006). Previous studies have shown that ages estimated from whole otoliths can

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be accurate (Maceina and Betsill, 1987) or, at least similar to ages estimated from sectioned otoliths (Isermann et al., 2003; Long and Fisher, 2001). However, in some instances, agreement between whole and sectioned otolith ages may only occur for relatively young fish within a population (Brouwer and Griffiths, 2004; Hoyer et al., 1985; Dembkowski et al., 2017).

As an alternative to scales and otoliths, use of fin spines for estimating fish age has increased over the last two decades, especially for percids (Logsdon, 2007; Niewinski and Ferreri, 1999; Vandergoot et al., 2008). Niewinski and Ferreri (1999) reported that among-reader precision was highest when using sectioned otoliths to estimate ages of yellow perch from Pymatuning Reservoir, Pennsylvania, but suggested scales and sectioned dorsal spines could be used to describe age and growth because ages were similar among structures and reader precision was relatively high (coefficients of variation [CV] < 10%). Similarly, Vandergoot et al. (2008) suggested that otoliths and anal fin spines be used for estimating the ages of Lake Erie yellow perch, as fin spines provided among-reader precision and mortality estimates that were similar to otolith-based estimates.

Growth of yellow perch in the Great Lakes is typically described using mean TLs at age based on fish TLs measured at time of capture. However, back-calculating lengths at previous ages based on the relationship between fish length and the diameter or radius of calcified structures offers another approach to describing growth (Francis, 1990). Back-calculation is more labor intensive, but increases the amount of growth information that can be obtained from an individual fish, which is desirable in cases where sample sizes are relatively low or populations are sampled infrequently. Back-calculation of fish lengths at previous ages has been routinely conducted using both scales (Pierce et al., 1996; Pierce et al., 2006; Ricker, 1992) and otoliths (Blackwell and Kaufman, 2012; Erickson, 1983; Schramm Jr. et al., 1992), but studies utilizing back-calculated lengths from spines are rare. Sneed (1951), Hirethota and Ringler (1993), and Michaletz et al. (2009) used pectoral spines to estimate back-calculated lengths at age for ictalurids, and Borkholder and Edwards (2001) demonstrated that back-calculated lengths at age estimated from dorsal spines were similar to those estimated from scales for walleyes *Sander vitreus*. However, Meerbeek and Hawkins (2013) reported that lengths back-calculated from walleye dorsal spines significantly overestimated growth. To our knowledge, no previous study has assessed the use of fin spines for back-calculating lengths at age for yellow perch.

The Wisconsin Department of Natural Resources (WDNR) manages both sport and commercial fisheries for yellow perch in the Wisconsin waters of Green Bay. Harvest is managed via annual harvest quotas that are based on projections of population biomass obtained from a statistical catch-at-age (SCAA) model. Age structure and TL-at-age information represent critical inputs to the SCAA model. Since the late 1970s, the WDNR has used scales to estimate the age of yellow perch <150 mm TL and anal fin spines to estimate age of perch ≥150 mm TL. Growth is described using mean TL at age at time of capture (i.e., no back-calculation). Yellow perch sampled from the size-selective commercial fishery (i.e., regulated by a minimum TL limit of approximately 190 mm) are included in estimates of growth, so current WDNR estimates of growth may be biased. Biased estimates of mean TLs at age of capture could result in biased estimates of total biomass, resulting in harvest quotas that are either larger than what is sustainable or are too conservative, preventing additional harvest that would be considered sustainable. Also, WDNR estimates of mean TL at age used in SCAA models include fish caught from various times during the open water season (i.e., spring, summer, and fall). If more yellow perch are sampled from a single time period, growth estimates may be biased. Use of back-calculation to estimate yellow perch growth would avoid some of the potential biases associated with WDNR sampling.

The primary objective of our assessment was to determine if age estimates, among-reader precision, and mean back-calculated TLs at age differed when scales, anal fin spines, and otoliths were used to estimate age and growth of yellow perch collected from southern Green Bay. While addressing this objective, we compared mean back-calculated TLs at age estimated using different measurement transects and back-calculation models.

Methods

Sampling

Yellow perch ($N = 156$) were collected in southern Green Bay by the WDNR during August 2009 bottom trawl surveys, fall 2009 commercial harvest surveys, and 2010 spring spawning assessments. Scales, sagittal otoliths, and the second anal fin spine were removed from a maximum of 10 yellow perch in each 10 mm TL group between 100 and 300 mm (11 fish were collected from one TL group) and from all perch over 300 mm TL (Fig. 1). Scales were removed from the left side of the fish under the lateral line and directly behind the depressed pectoral fin (DeVries and Frie, 1996). Sagittal otoliths were removed, and a pair of side cutters was used to remove the entire anal fin. Scales and spines were placed in coin envelopes after removal and otoliths were placed in plastic vials. All structures were allowed to dry and were stored for a period ≥6 weeks prior to age estimation.

Age estimation

Whole otoliths were submerged in water within a black dish and digital images (20× magnification) were captured using an Insight® Firewire® (Model # 14.2 Color Mosaic) digital camera mounted on a Nikon® SMZ1500 dissecting microscope using SPOT Advanced® software. One otolith from each fish was set in an epoxy resin (5:1 mixture of Buehler® Epo-Kwick® Resin and Buehler® Epo-Kwick® Hardener). One 0.4-mm thick transverse section was cut through the focus of each otolith using a low speed Buehler® Isomet® 1000 Precision Saw mounted with a Buehler® diamond wafering blade (15.2 cm × 0.5 mm). Each otolith section was mounted to a microscope slide

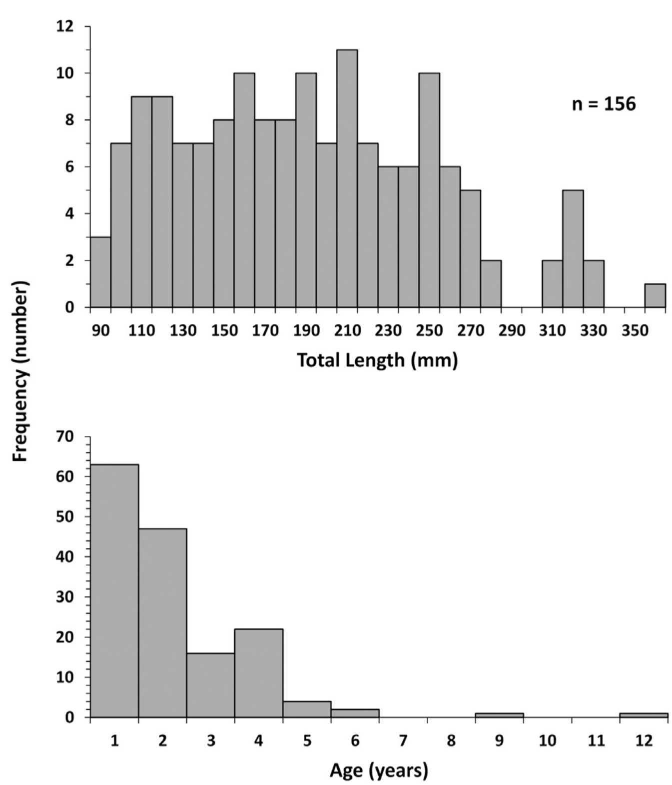

Fig. 1. Total length (mm) and age frequencies based on consensus sectioned otolith ages for yellow perch collected in Green Bay, Lake Michigan.