INFLUENCE OF HATCH TIMING AND DAILY GROWTH RATE ON SIZE STRUCTURE OF AGE-0 LARGEMOUTH BASS COHORTS IN ENEMY SWIM LAKE, SOUTH DAKOTA

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ABSTRACT

Hatch timing can influence growth and survival of age-0 largemouth bass *Micropterus salmoides* populations and has not frequently been analyzed for largemouth bass in northern natural lakes. This study describes hatching events of age-0 largemouth bass in Enemy Swim Lake, a glacial lake in northeastern South Dakota during 2000-2002, and determined the potential effects of hatch timing and daily growth rates (mm/d) on size of age-0 largemouth bass collected in late summer seine hauls. Hatching occurred between May 20 and July 7; mean hatch date ranged from May 30 to June 11, indicating that peak hatching generally occurred between late May and mid June. Mean hatch dates were significantly different among all years; differences ranged from 5 to 11 d. On average, largemouth bass grew 0.76 mm/d (N = 93; SE = 0.01) and daily growth rates did not significantly differ among years. A significant negative correlation (r = -0.50, df = 25, P = 0.01) existed between hatching date and daily growth rate for age-0 largemouth bass in 2002, indicating that earlier-hatched bass exhibited faster growth than later-hatched individuals. Significant relations between hatch date and daily growth were not apparent in 2000 and 2001. Multiple regression modeling indicated that hatch date and daily growth explained nearly all of the variability in total length (TL) of age-0 largemouth bass captured in August seine hauls (R^2 > 0.97); the amount of variation explained by each independent variable varied across years. Hatch timing did influence TL of age-0 largemouth bass as reported in other studies; however, variation in daily growth played an important role in regulating TL attained by age-0 largemouth bass and was not always related to hatch timing. Among-year variability in daily growth of age-0 individuals should be considered in future studies of population dynamics and recruitment patterns in largemouth bass populations.

INTRODUCTION

First year survival of age-0 largemouth bass *Micropterus salmoides* may regulate relative abundance of young of the year bass populations (Goodgame and Miranda 1993; Ludsin and DeVries 1997; Post et al. 1998). Previous research has investigated the influence of hatching date on size dependent mortality of age-0 largemouth bass (Goodgame and Miranda 1993; Kohler et al. 1993; Ludsin and DeVries 1997; Post et al. 1998; Sammons et al. 1999). Sammons et al. (1999) found that earlier hatched largemouth bass had increased survival during the first year of life in one Tennessee reservoir. Conversely, Kohler et al. (1993) found that survival of age-0 largemouth bass was not related to peak hatching date in an Illinois reservoir. Additionally, Fuhr et al. (2002) determined that abundance of age-1 largemouth bass was related to the density of age-0 bass prior to their first winter, regardless of their size. Ludsin and DeVries (1997) found four factors that were critical to age-0 largemouth bass survival: hatching date, the shift to a piscivorous diet, autumn lipid accumulation, and first winter mortality. Goodgame and Miranda (1993) suggested that length advantages exhibited by earlier-hatched individuals persisted throughout the growing season. Earlier-hatched largemouth bass may become piscivorous at a younger age and sustain higher levels of piscivory throughout the growing season than their later hatched counterparts (Phillips et al. 1995), resulting in improved lipid accumulation and increased winter survival (Ludsin and DeVries 1997). Differences in survival probabilities between faster and slower growing fish of the same cohort become more pronounced by factors influencing competition and predation (Coutant and DeAngelis 1983). Hence, daily growth rate may also affect age-0 largemouth bass survival because fish that grow faster may achieve greater total lengths than slower growing members of the same cohort.

The purpose of our study was to estimate the hatching date and calculate daily growth rates for largemouth bass from Enemy Swim Lake, South Dakota. Additionally, we evaluated the effects of hatch date and daily growth on size structure of age-0 largemouth bass prior to their first winter.

STUDY AREA

Enemy Swim Lake is an 884-ha (mean depth = 4.8 m, maximum depth = 10.0 m) natural lake of glacial origin located in the prairie pothole region of northeastern South Dakota in Day County. Enemy Swim Lake has been described as mesotrophic to eutrophic (Stueven and Stewart 1996). Submergent and emergent vegetation coverage in late summer is near 30% with silt composing the majority (55%) of the substrate (Blackwell 2001). The fish community of Enemy Swim Lake includes black crappie *Pomoxis nigromaculatus,* largemouth bass, smallmouth bass *Micropterus dolomieu,* yellow perch *Perca flavescens,* bluegill *Lepomis macrochirus,* pumpkinseed *Lepomis gibbosus,* common carp *Cyprinus carpio,* white bass *Morone chrysops,* northern pike *Esox lucius,* walleye *Sander vitreus,* white sucker *Catostomus commersoni,* johnny darter *Etheostoma nigrum,* black bullhead *Ameiurus melas,* rock bass *Ambloplites rupestris,* and spottail shiners *Notropis hudsonius.*

METHODS

Collection

Age-0 largemouth bass were collected in seine hauls (15.3-m long, 6.4-mm bar mesh) from Enemy Swim Lake during the first week of August from 2000 to 2002. Twenty-four sites were sampled annually to capture age-0 largemouth bass. Sample sites were chosen randomly and remained fixed throughout the study. All bass captured within each seine haul were identified to species and age-0 largemouth bass were measured (total length; TL) to the nearest mm.

Laboratory Analysis

Sagittal otoliths were removed, using techniques described by Schmidt and Fabrizio (1980), from randomly selected age-0 largemouth bass for hatch date estimation. After removal, sagittal otoliths were wiped clean and allowed to air dry in numbered vials for 2 weeks prior to enumeration of daily rings. One whole otolith from each age-0 largemouth bass was secured to a microscope slide using a small amount of cyanoacrylic cement (Miller and Storck 1982). Otoliths were viewed using a compound microscope (400x magnification) that projected images to a television monitor to aid in the enumeration of daily rings. Three separate counts (per otolith) were made by one individual reader and average daily ring counts were used in estimating hatch date. Some otoliths were lightly polished with wetted 1000-grit sand paper and immersion oil was used to improve clarity.

Hatching Date

Miller and Storck (1982) determined from laboratory analysis that age-0 largemouth bass were 7- to 8-d old at swim-up. Thus, hatch date estimations were calculated using the following equation:

hatch date = day of capture – (average daily ring count + 7 d).

Daily growth

Prior research indicated that total length of age-0 largemouth bass at swim-up was approximately 5 mm (Miller and Storck 1982). Therefore, the following equation was used to determine daily growth rates (mm / d) over the period from swim-up until time of capture in August seine hauls:

daily growth = (TL at capture – 5 mm) / average daily ring count.

Statistical Analyses

Relative abundance of age-0 largemouth bass among years was described using mean catch per unit effort (CPUE; catch per seine haul). Mean hatch dates, mean TL, and mean daily growth rates were compared among years using analysis of variance (ANOVA) and multiple comparisons were made using

Bonferroni procedures (α = 0.05). The relationship between daily growth and hatching date was evaluated for each year using Pearson correlations. For individual years, stepwise multiple regression was used to determine the relative importance of hatch date and daily growth in explaining variation in TL of age-0 largemouth bass collected in August.

RESULTS AND DISCUSSION

The mean CPUE of age-0 largemouth bass ranged from 1.18 (SE = 0.3) to 3.4 (SE = 2.7) among years, and August seining length-frequency distributions were unimodal in nature (Fig. 1). Mean TL of age-0 largemouth bass ranged from 45 to 55 mm across years (Fig. 1); mean TL in 2002 (45 mm) was significantly lower than in 2000 and 2001 (55 mm; $P < 0.05$). Similarly, Toneys and Coble (1979) reported mean total lengths of 52.7 mm ± 9.7 mm for age-0 largemouth bass captured during the fall in Thomas Lake, Wisconsin. Keast and Eadie (1985) recorded comparable total lengths (37 mm – 63 mm) for age-0 largemouth bass in Lake Opinicon, Ontario collected in September.

Hatching dates of age-0 largemouth bass occurred from May 20 (day 140) until July 7 (day 187) with mean hatching date ranging from May 31 (day 151) to June 11 (day 162; Figure 2). Over the course of the evaluation, hatching duration in Enemy Swim Lake ranged from 24 to 44 d. Sammons et al. (1999) found that largemouth bass in Normandy Reservoir had hatch durations of 35 to 68 d, while Phillips et al. (1995) reported that bass captured in a 64-ha embayment of B. Everett Jordan Lake, North Carolina hatched over a 70-d period. Extended hatching windows could be caused by protracted spawning periods for largemouth bass that may be attributed to local weather, changes in water temperature, or interspecific competition (Schmidt and Fabrizio 1980). Additionally, hatch date distributions of age-0 largemouth bass in Enemy Swim Lake were generally unimodal (Fig. 2); however a 15-d gap occurred in hatch date distribution dur-

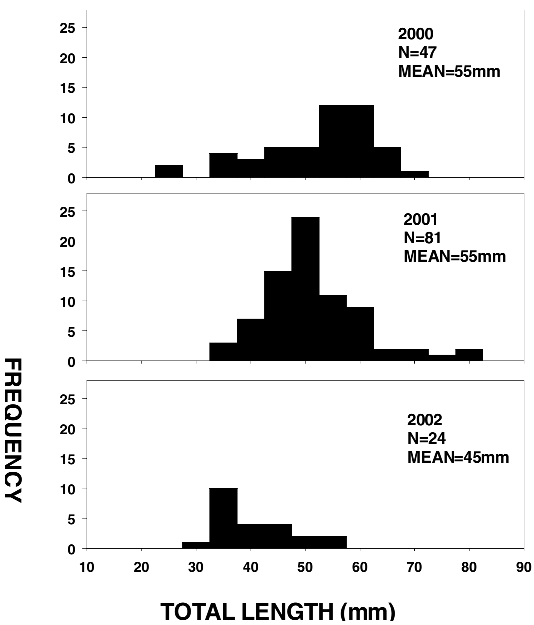

Figure 1. Length-frequency distribution for age-0 largemouth bass captured during August seine hauls in Enemy Swim Lake, South Dakota from 2000 to 2002.

ing 2000, where a small proportion of fish (14%, 5 of 30) hatched between June 10 (day 162) and June 15 (day 177). Mean hatching dates were significantly different among years (F = 17.67; df = 2, 90; P = 0.0001). Multiple comparisons revealed that mean hatch date occurred significantly later in 2000 and 2002 than in 2001 (7-12 d later; $P < 0.05$); mean hatch date did not significantly differ between 2000 and 2002.

Mean daily growth rate of age-0 largemouth bass in Enemy Swim Lake over the 3-year period was 0.76 mm/d (SE = 0.01). Phillips et al. (1995) found similar daily growth rates, ranging from 0.51 to 1.04 mm/d for age-0 largemouth bass captured in North Carolina. Mean daily growth rate did not significantly differ among years and ranged annually from 0.74 (SE = 0.03) to 0.80 (SE = 0.03) mm/d. Daily growth rate was negatively related to hatch date in 2002 (r = -0.50, df = 25, P = 0.01; Fig. 3), indicating that earlier hatched age-0 largemouth bass tended to experience faster growth than later hatched fish from that cohort. Similarly, Goodgame and Miranda (1993) found that earlier hatched age-0 largemouth bass experienced faster growth rates and attained greater total lengths by

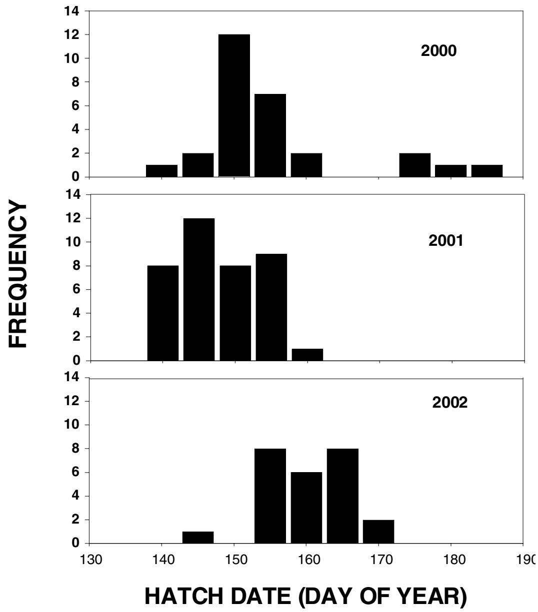

Figure 2. Hatch date distributions for age-0 largemouth bass collected during August seine hauls in Enemy Swim Lake, South Dakota from 2000 to 2002.

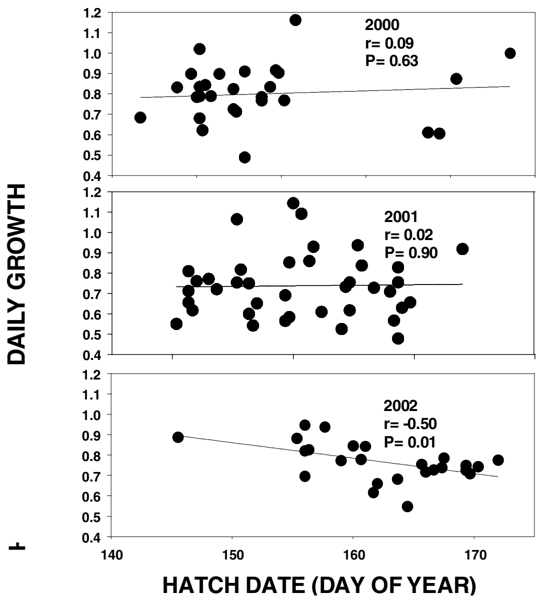

Figure 3. Daily growth rate as a function of hatching date for age-0 largemouth bass that were sampled during August seine hauls in Enemy Swim Lake, South Dakota from 2000 to 2002.

time of collection than later hatched bass of the same cohort. However, no significant relations between daily growth and hatch date for age-0 largemouth bass were detected in 2000 or 2001 (Figure 3).

Hatch date and daily growth rate explained > 97% of the variation in TL of age-0 largemouth bass collected in August seine hauls ($R^2 > 0.97$; P = 0.0001) in all three years. Based on partial coefficients of determination (r^2), hatch date explained the majority of the variation in TL (r^2 = 0.50-0.76; P = 0.0001) in regression models for 2000 and 2002, with daily growth rate explaining the remaining variation in the model (r^2 = 0.24-0.48; P = 0.0001). However, in 2001 daily growth rate explained over 80% of the variability in TL of age-0 largemouth bass collected in August (r^2 = 0.81; P = 0.001) with hatch date explaining the remaining variability (r^2 = 0.19; P = 0.0001). Multicollinearity may have existed between hatch date and daily growth in 2002 based on the significant correlation between these two variables that year.

Our study indicated that hatch date and daily growth determined total length attained by age-0 largemouth bass by time of capture in August. Because age-0 largemouth bass survival can be length dependent, bass that have faster growth rates and hatch earlier may achieve a larger total length during their first growing season and could be less vulnerable to predation (Goodgame and Miranda 1994), have lower overwinter mortality (Miranda and Hubbard 1994; Post et al. 1998), and have greater ability to shift to a piscivorous diet sooner than others of the same cohort (Phillips et al. 1995). Therefore, hatching date and daily growth rate could influence the relative abundance of age-1 largemouth bass.

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