



Assessment of the vertical distribution of larval lake sturgeon drift in the Peshtigo River, Wisconsin, USA

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Summary

Drift nets have been used to document reproductive success of lake sturgeon *Acipenser fulvescens*. Current net designs and methods for collecting drifting larvae only sample a portion of the water column, which require assumptions of either a benthic or uniform distribution of larvae when estimating abundance or production. The objective of this study was to describe the vertical distribution of larval lake sturgeon in the Peshtigo River, Wisconsin, and to determine if drift was benthic or uniform in distribution. A net was designed to assess the vertical distribution of drifting larvae in 0.2-m increments at depths up to 1.4 m; however, during this sampling, maximum depth did not exceed 0.78 m. The distribution of larval lake sturgeon was neither benthic nor uniform. Only 5% of larvae were captured in the lowest 0.2-m increment, followed by 18% from 0.2 to 0.4 m, 41% from 0.4 to 0.6 m, and 36% from 0.6 m to the surface. Although results will likely differ among years, systems, and the precise location of sampling, our study illustrates the importance of and provides a technique for testing assumptions of the vertical distribution of larval lake sturgeon drift.

Introduction

Understanding the dynamics of early life stage recruitment has been recognized as a critical component to sturgeon rehabilitation (Auer, 1999; Secor et al., 2002). Catches of larval lake sturgeon, *Acipenser fulvescens*, made during their drift from hatching to nursery areas, have been used to document spawning success (Kempinger, 1988). In addition, sampling of the larval life stage has allowed for an increased understanding of lake sturgeon life history, including the timing, distribution, duration, and distance of drift behavior (LaHaye et al., 1992; D'Amours et al., 2001; Auer and Baker, 2002; Smith and King, 2005; Benson et al., 2006).

Lake sturgeon larvae have been captured using a variety of sampling protocols. Drift nets used to collect this life stage include conical-, D-, and rectangular-frame nets. Conical nets up to 1 m in diameter have been used for sampling, but most D- and rectangular-frame nets are <0.5 m in height. These nets are most commonly deployed on the bottom of rivers (Kempinger, 1988; LaHaye et al., 1992; Auer, 1999; Benson et al., 2006), but have also been used at mid-water depths (D'Amours et al., 2001) and near the surface (Kempinger, 1988; D'Amours et al., 2001). Although drifting larvae have

been captured at mid-water depths and near the surface, most collections of larvae have been along the bottom. However, the entire water column is not sampled during these collections, resulting in an incomplete description of the vertical distribution of larval sturgeon.

Catches of larval lake sturgeon are typically reported as catch-per-unit-effort (CPUE), and these relative values are used for comparison of populations (Kempinger, 1988; Auer and Baker, 2002; Smith and King, 2005; Benson et al., 2006). Because of annual, temporal, and spatial variability in habitat types, environmental conditions, and sampling effort, these CPUE data may provide biased comparisons of recruitment potential. Estimates of absolute abundance could provide a more reliable measure of spawning success and allow comparisons of productivity both among years and populations (Benson et al., 2006). The availability of abundance data should result in a more complete understanding of recruitment dynamics, which would facilitate the development of appropriate science-based restoration strategies for lake sturgeon and other sturgeon species.

If the absolute abundance of larval lake sturgeon is to be estimated without a complete description of the vertical distribution, one of two assumptions must be made concerning larval drift. Because lake sturgeon are benthic, it is often assumed that larvae drift near the substrate, suggesting that benthic drift nets would capture most individuals passing through the sampled section of the river (Auer and Baker, 2002; Smith and King, 2005). Alternatively, if larvae are distributed uniformly throughout the entire water column, the volume of water sampled and larval catches in each net should be proportional to the volume of water and number of larvae passing the entire drift net site (Veshchev et al., 1994; Smith and King, 2005). To date, neither of these assumptions has been validated. If either assumption is violated, estimates of larval abundance would be biased; therefore, the vertical distribution of larvae must be described before reliable abundance estimates can be made with traditional sampling gear. The objective of this study was to describe the vertical distribution of larval lake sturgeon in the Peshtigo River, Wisconsin, during the 2007 drift period and test the assumptions of whether drift was benthic or uniform in distribution.

Materials and methods

Net construction

Each sampling net consisted of a single main support structure and multiple rectangular net frames stacked on the main support structure while fishing (Fig. 1a). The main support

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structure (150 cm high \times 70 cm wide) was fabricated from 1.9 cm diameter stainless steel rod welded into a square-bottomed 'U' shape. A 3.8 cm diameter stainless steel ring was welded to each corner along the bottom of the main support structure for anchor attachment. Each rectangular net frame was constructed from 0.8 cm diameter stainless steel rod welded into rectangles 20 cm in height and 70 cm in width. Attached to each rectangular net frame was a 240 cm long collection bag fabricated from 0.16-cm mesh. Nylon thread was used to attach the collection bag to the rectangular frame and to close the end of the bag with a straight stitch. A 3.8 cm diameter stainless steel ring was then welded to each corner of the rectangular frames, allowing each net to slide over the main support structure in a stacked design. Up to seven rectangular nets could be stacked on one main support structure, providing the ability to completely sample the water column to a depth of 1.4 m. A double-claw trap-net anchor held each net in place; however, in areas where surface current velocities exceeded 0.60 m s^{-1} , two trap-net anchors were used in tandem to ensure the net was not displaced by the current. Zinc-plated link chain (links 4 mm in diameter and 25 mm long \times 13 mm wide) was used to connect the anchors to the rings at the base of the main support structure by means of carabiner clips. A second line of chain and clips was used to connect the anchors to the top ring of the uppermost rectangular net frame to provide vertical support (Fig. 1b). Chain was used so that the number of rectangular net frames and angle of the support structure could be easily adjusted at different depths and velocities. The cost in 2007 to construct one net was U.S. \$750.

Larval drift sampling

Nets of this design were used to assess the vertical distribution of larval lake sturgeon during the peak drift period from 13 to 17 May 2007 in the Peshtigo River, Wisconsin (N45°03.151', W87°44.794'). Two support structures were placed along a transect perpendicular to the current, approximately 100 m below the known lake sturgeon spawning area. Water depths during the 5 days of sampling did not exceed 0.78 m; thus, only four rectangular nets were required on each support structure to sample the entire water column. Nets were deployed each day from 20.00 to 02.00 h (Kempinger, 1988), and each rectangular net was emptied on an hourly basis. The water velocity at the mouth of each individual net frame was

measured using a Price AA flowmeter attached to a top-set wading rod (Scientific Instruments Inc., Milwaukee, WI). Debris in each net was minimal and reduced water velocities due to net clogging were not observed. To remove the contents from each net, the main support frame was held in place while the rectangular net frames were removed and taken to shore. Because larval fish accumulated in the back of the collection bag, each bag was inverted and contents emptied into a bucket. The rectangular frames were then placed back on the support structure to continue sampling. The process of removing, emptying, and resetting the nets took 5–10 min. The number of live and dead larval lake sturgeon were recorded for each hourly sample in each rectangular net, and live fish were released downstream of the sampling location.

Data analysis

Chi-square tests were used to determine if the distribution of larvae in the water column was uniform or benthic. The river depth sampled in 2007 ranged from 0.74 to 0.78 m and averaged 0.76 m, thus four stacked rectangular net frames were required to sample the entire water column. Nets sampled from 0 to 0.20 m, 0.20 to 0.40 m, and 0.40 to 0.60 m from the bottom, and 0.60 m from the bottom to the surface. Measured water velocities were used to determine the volume of water passing through each vertical net each night of sampling. Under a uniform distribution larvae were expected to be captured in proportion to the amount of water sampled by each net. For the benthic drift evaluation, it was assumed that 95% of the larvae should be captured in the lower two nets, with the remaining 5% occurring in the upper two nets. This would have represented nearly complete capture in benthic-set traditional sampling gear 0.4 m in height. Statistical analyses were conducted using SIGMASTAT 3.5 (Systat Software, Inc., San Jose, CA), and all results were considered significant at the $\alpha = 0.05$ level.

Results and Discussion

A total of 237 larvae were captured during 60 h of effort. No yolk-larvae were captured and all drifting larvae were between 16 and 22 mm in total length. The vertical distribution of drifting lake sturgeon larvae was neither benthic nor uniform ($\chi^2 = 2587$ and $\chi^2 = 30.0$, respectively, both $P < 0.01$), and larvae were observed nearer to the surface than expected.

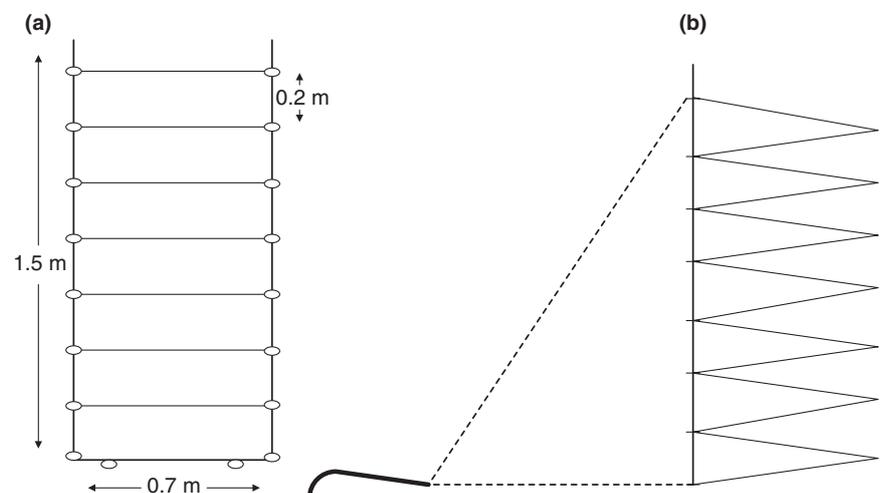


Fig. 1. Sampling net used to determine vertical distribution of drifting larval lake sturgeon (*A. fulvescens*): (a) front view of net structure with maximum number of individual nets stacked on it; (b) side view of structure when fishing; dashed lines = chains connecting net structure to anchor(s). Note: collection bags 240 cm long, not drawn to scale

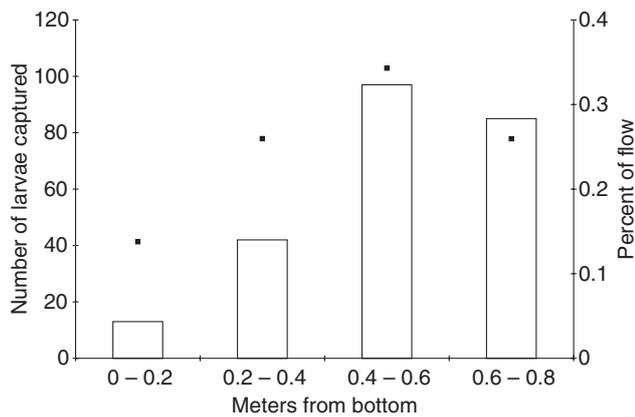


Fig. 2. Vertical distribution of larval lake sturgeon (*A. fulvescens*) during 2007 drift period in the Peshtigo River, Wisconsin, USA. Bars and points = number of larvae captured and percent of flow in each position, respectively

Fourteen percent of the total flow passing through the vertical nets 14% occurred within 0.2 m of the river bottom, although only 5% of larvae were captured in this position. Between 0.2 and 0.4 m from the bottom, 18% of larvae were captured despite 26% of flow passing through this position. Thirty-four percent of the total flow passed between 0.4 and 0.6 m from the bottom, but 41% of the larvae were observed in this position. The remaining 26% of flow passed between 0.6 m from the bottom and the surface; however, 36% of larvae were captured in this position (Fig. 2).

The results of sampling with the stacked net design suggest that the vertical distribution of larval lake sturgeon drift in the Peshtigo River in 2007 was neither benthic nor uniform. Although information on the vertical drift characteristics of lake sturgeon is limited, studies of other sturgeon species show that variation exists in larval drift position in the water column, and assumptions of benthic or uniform drift are not met. In a 150-cm deep artificial stream tube, some shortnose sturgeon *A. brevirostrum* larvae moved downstream along the bottom, but the majority swam above the bottom at an average height of 100 cm (Kynard and Horgan, 2002). In a similar stream tube, pallid sturgeon *Scaphirhynchus albus* and shovelnose sturgeon *S. platorhynchus* drifted mostly downstream at the surface (Kynard et al., 2002), and white sturgeon *A. transmontanus* larvae moved downstream at an average height of 4–58 cm from the bottom (Kynard and Parker, 2005). In the Fraser River, British Columbia, sampling with D-frame drift nets captured one white sturgeon larvae at the surface and all others on the bottom; however, mid-water depths were not sampled (Perrin et al., 2003). The results of these studies suggest that the vertical distribution of sturgeon larvae is variable. Therefore, sampling only a portion of the water column may preclude the capture of a significant percentage of drifting larvae. Given the vertical distribution of larval lake sturgeon observed in the Peshtigo River in 2007, if assumptions of benthic or equal drift were accepted and only benthic sampling occurred, abundance estimates would have been negatively biased.

In the Peshtigo River, lake sturgeon larvae were captured drifting throughout the water column, but were found nearer to the surface than the bottom. This distribution was observed only 100 m downstream of the spawning area in 0.78 m of water; it likely will differ among years, rivers, and the location of sampling within rivers due to variability in flow, river

morphology, and larval characteristics. In the Wolf River, Wisconsin, Kempinger (1988) used two stacked rectangular-frame drift nets to sample nearly the entire water column and captured more lake sturgeon larvae in the bottom net in 1 year, followed by more larvae in the upper net the next year. In the Des Prairies River, Quebec, D'Amours et al. (2001) did not sample the entire water column, but used nets on the surface and bottom and captured more larvae in the surface nets in one year, followed by more larvae in the bottom nets in the next year. These results indicate that annual variation may be expected, and sampling the vertical distribution of drifting larvae each year is necessary to both test assumptions about drift and to assess the accuracy of counts made in traditional gear that only samples a portion of the water column.

Characterizing the vertical distribution of lake sturgeon larvae during drift is an important factor in determining the accuracy of population measures and recruitment potential. The net design presented here is intended for use at wadeable transects and will provide the vertical distribution of drifting larvae passing the sampling site. In some rivers, shallow transects (<1.4 m deep) that fit this criteria are not available. In these areas, assessing the vertical distribution and abundance of larvae is more difficult. It remains unclear if drifting larval sturgeon orient near the surface or a certain distance from the bottom; therefore, it is difficult to predict their response and vertical distribution in deep areas. Larval catches in non-wadeable rivers that are the result of only sampling portions of the water column cannot be used to make accurate comparisons of productivity between years or rivers, as large portions of the drifting population may be missed and that proportion may vary between years.

A consequence of sampling with this vertical net design may be an increase in the mortality rate of captured lake sturgeon larvae. The mortality rate of lake sturgeon larvae collected during this sampling was 16%. Although it is unknown whether mortality occurred before or after individuals entered the net, standard D-frame nets with collection cups were simultaneously used to sample larvae during the 2007 drift period, and mortality rates were half (8%) of that observed in the vertical nets (D. Caroffino, unpubl. data). Mortality rates may be reduced if collection cups are placed at the end of the mesh bags rather than a straight stitch closure.

The vertical nets described in our study can be used exclusively or adjacent to traditional sampling gear when drift protocols call for estimates of larval sturgeon abundance. Traditional drift nets effectively sample the entire water column only when water depths are less than or equal to the height of the net mouth. At greater water depths, vertical stacked drift nets should be utilized to assess the vertical distribution of drifting larvae. Catches in these nets may also be used to determine correction factors so that catches in gear not sampling the entire water column can be adjusted for unequal drift.

Although intended for use in larval lake sturgeon studies, this vertical net design can be used to sample a variety of larval fish in river systems. Other sturgeon species, as well as some members of Cyprinidae, Catostomidae, Salmonidae, and Hiodontidae demonstrate similar larval drift behavior and occupy small, wadeable rivers (Naesje et al., 1986; D'Amours et al., 2001; Kynard et al., 2002; Kynard and Horgan, 2002; Perrin et al., 2003; Johnson and McKenna, 2007). To reduce bias of larval collections, sampling the vertical distribution with nets such as those described here should be an integral part of any drift sampling protocol.

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