Critical Current Speeds for Young Gulf Coast Walleyes

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Abstract.—We evaluated critical current speeds (CCS, cm/s) for young Gulf (of Mexico) Coast walleyes Stizostedion vitreum and compared the results to field determinations of water velocity under different flood conditions in Luxapalilia Creek, Mississippi, which supports a small population of this species. Critical current speeds for actively feeding walleyes ranged from 8 to 74 cm/s, and were related to fish standard length (SL, mm) by \( \log_{10}(\text{CCS}) = -0.231 + 0.927 \log_{10}(\text{SL}) \), for which \( P < 0.0001, r^2 = 0.67, \) and \( N = 83 \). Mean current velocities in Luxapalilia Creek between May and June ranged from 20 to 45 cm/s. Means were higher than the CCS for a young walleye at that time, but velocities were spatially variable. Persistence of walleyes in Luxapalilia Creek and similar streams probably depends on the availability of instream structures that locally reduce current speed. Removal of such structures or channelization of such streams could compromise the survival of a genetically unique southern population of walleye.

The intensity and frequency of floods can adversely affect survival and growth of larval and juvenile fishes (Power et al. 1988; Simonson and Swenson 1990; Harvey 1991). Stream fishes often use low-velocity areas associated with obstructions to escape the effects of floods (Meffe 1984). These “current refugia” can reduce the risk of being swept downstream (Brown and Armstrong 1985; Harvey 1987; Ross et al. 1992), reduce the energetic cost of maintaining position in a stream (Fausch 1984; Pearsons et al. 1992), reduce predation risk (Angermeier and Karr 1984), and provide sites of increased prey density (Angermeier and Karr 1984; Benke et al. 1985). Survival and subsequent recruitment of many stream fishes are linked to current velocity and foraging abilities (Miller et al. 1992).

The Gulf (of Mexico) Coast population of wall-
cm according to fish size. A single walleye was placed into the artificial stream 3 min before each trial ($N = 83$; no fish was used twice). Water velocity was then increased steadily with two Teel submersible pumps. A CCS was reached when the fish no longer maintained a fixed position over a black line on the stream bottom (Matthews 1985). Fish were recaptured from the lower reservoir and measured (SL = ±0.1 mm). Water velocity was measured with a Marsh–McBirney current meter model 201D at the position where the fish had been displaced.

In Luxapalilia Creek, a third-order stream in northeastern Mississippi (Tombigbee drainage), water velocity was measured within six bank-to-bank, 3-m-wide transects within a representative 1-km section of an unchannelized reach on four occasions covering May–July 1993 and February 1994. Each transect was divided into a series of $1 \times 3$-m contiguous cells, and water velocity at the center of each cell (10 cm below the surface) was measured with a Marsh–McBirney current meter. This sampling included high and low water levels; discharges were 2.78 m$^3$/s in July and 39.36 m$^3$/s in February. Data given in this paper are midchannel water velocities averaged over the six transects. Water discharge (m$^3$/s) was obtained from the U.S. Geological Survey gauge station on Luxapalilia Creek (about 1.5 km downstream from our study site) for the days transects were surveyed. Discharges on the days we sampled were typical of seasonal values for Luxapalilia Creek (see Peterson and VanderKooy 1995).

All statistical procedures were completed with SPSS PC+ (SPSS Inc., version 5.0 [1992], Chicago, Illinois). Least-squares regression was used to model CCS versus SL. We used the outlier analysis of SPSS (data with residuals exceeding three standard deviations above or below the mean) as a first step to determine if specific cases were outliers. If outliers were identified, we then used Hat matrix leverage, Cook’s distance, DFFIT, and DFBETA metrics to determine if these cases were influential as well. Data were log$_{10}$-transformed prior to analysis to conform to the regression assumption of normality. Significance was determined at $P < 0.05$.

**Results**

One outlier was delineated in our laboratory analysis, but the Hat matrix leverage, Cook’s distance, and DFFIT and DFBETA metrics all indicated that this case was not influential. The CCS for an actively feeding walleye was size dependent over the range of water speed tested (8–74 cm/s; Figure 2).

Water velocities in Luxapalilia Creek varied with discharge (Table 1), which were related to seasonal rainfall patterns (Peterson and VanderKooy 1995) over the course of this study. Mean values ranged from 18 cm/s in late July to 96 cm/s in mid-February.

**Discussion**

Survival of juvenile fishes in rivers can be influenced by many factors such as turbidity, pH, dissolved oxygen concentration, and fluctuations in stream flow (Ross et al. 1985; Power et al. 1988; Meffe and Sheldon 1990). Our data suggest that survival of young Gulf Coast walleyes may be decreased at high flow unless habitat of reduced velocity is available. Current velocities in Luxapalilia Creek in May and June averaged 20.0–45.0 cm/s (Peterson and VanderKooy 1995), which would prevent walleyes 30 mm or smaller from holding position in the open water of the creek during those months.

Our laboratory results and those of Houde (1969) suggest that young walleyes require habitats with lower water velocities than the mean velocities we measured in Luxapalilia Creek if they are to resist downstream displacement. The only low-velocity water available to walleyes during early life in streams is associated with woody structures, such as trees, stumps, and logs, or shallow stream margins (VanderKooy 1994). Partially submerged woody structures found along creek banks are relatively numerous between spring and early summer and provide areas of significantly slower flow (Angermeier and Karr 1984; Everett and Ruiz 1993; VanderKooy 1994). Meffe (1984) demonstrated that flood-resistant fishes survive by searching out...
slower velocities. Mills and Mann (1985) noted that current refuges were critical to the survival of larval cyprinids and dace and that successful recruitment may depend on flow levels in a particular year. After 6 July 1993, the midchannel mean water velocity in the Luxapalilia Creek was below the CCS for walleyes 30 mm SL and smaller. The range in the water velocity data among the six transects (all within 1 km of each other) suggests that spatial variation in flow may aid young walleyes in maintaining position. Young Gulf Coast walleyes might search for slower pools, backwater areas, or woody structures to escape faster currents and downstream displacement, as reported for northern populations of walleye (Kelso 1978; Corbett and Powles 1986; Pitlo 1989). As walleyes increase in size in late spring and summer, woody structures would become less important as current refugia.

Other factors may affect the survival of walleyes in Luxapalilia Creek, such as availability of suitable spawning habitats, the effect of siltation on egg viability, or predation upon later life history stages (Johnson 1977; Corbett and Powles 1986; Pitlo 1989). Our data suggest, however, that the widespread practice of channelizing streams and the associated snagging, clearing, and dredging of stream habitats might have an indirect effect on young Gulf Coast walleye and on any other species that requires low flow habitats. Because channelization and associated activities typically increase flood frequency and water velocities in coastal plain streams (Shankman and Pugh 1992), such activities may indirectly increase mortality of young walleyes.

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References


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**TABLE 1.** Discharges and associated water velocities in Luxapalilia Creek, Mississippi, on sampling dates corresponding to different river stages. Water velocity data are from the centers of six bank-to-bank transects and are presented as mean ± SD (range).

<table>
<thead>
<tr>
<th>Date</th>
<th>Discharge (m³/s)</th>
<th>Water velocity (cm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 Feb 1994</td>
<td>39.36</td>
<td>96.0 ± 31.0 (63–143)</td>
</tr>
<tr>
<td>8 May 1993</td>
<td>23.38</td>
<td>75.0 ± 24.0 (53–108)</td>
</tr>
<tr>
<td>6 Jul 1993</td>
<td>10.99</td>
<td>48.0 ± 22.0 (28–82)</td>
</tr>
<tr>
<td>30 Jul 1993</td>
<td>2.78</td>
<td>18.0 ± 9.0 (11–36)</td>
</tr>
</tbody>
</table>

**FIGURE 2.** Double-logarithmic (base 10) plot of critical current speed (CCS) versus standard length (SL) of walleyes ranging from 29.5 to 145.7 mm SL. The model is \( \log_{10}(\text{CCS}) = -0.231 + 0.927 \log_{10}(\text{SL}) \); \( P < 0.0001; r^2 = 0.67; N = 83 \).