Journal of Great Lakes Research 44 (2018) 491–496

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

# Lateral and vertical distribution of downstream migrating juvenile sea lamprey

V. Alex Sotola [a], Scott M. Miehls [b,*], Lee G. Simard [a], J. Ellen Marsden [a]

[a] Rubenstein Ecosystem Science Laboratory, University of Vermont, 3 College St., Burlington, VT 05401, United States
[b] U.S. Geological Survey, Great Lakes Science Center, Hammond Bay Biological Station, 11188 Ray Rd., Millersburg, MI 49759, United States

ARTICLE INFO

*Article history:*
Received 25 October 2017
Accepted 15 March 2018
Available online 5 April 2018

Communicated by Tim Johnson

*Keywords:*
Migration
Transformer
Drift
Thalweg

ABSTRACT

Sea lamprey is considered an invasive and nuisance species in the Laurentian Great Lakes, Lake Champlain, and the Finger Lakes of New York and is a major focus of control efforts. Currently, management practices focus on limiting the area of infestation using barriers to block migratory adults, and lampricides to kill ammocoetes in infested tributaries. No control efforts currently target the downstream-migrating post-metamorphic life stage which could provide another management opportunity. In order to apply control methods to this life stage, a better understanding of their downstream movement patterns is needed. To quantify spatial distribution of downstream migrants, we deployed fyke and drift nets laterally and vertically across the stream channel in two tributaries of Lake Champlain. Sea lamprey was not randomly distributed across the stream width and lateral distribution showed a significant association with discharge. Results indicated that juvenile sea lamprey is most likely to be present in the thalweg and at midwater depths of the stream channel. Further, a majority of the catch occurred during high flow events, suggesting an increase in downstream movement activity when water levels are higher than base flow. Discharge and flow are strong predictors of the distribution of out-migrating sea lamprey, thus managers will need to either target capture efforts in high discharge areas of streams or develop means to guide sea lamprey away from these areas.

Published by Elsevier B.V. on behalf of International Association for Great Lakes Research.

## Introduction

Sea lamprey (*Petromyzon marinus*) are considered an invasive and nuisance species in the Laurentian Great Lakes, Lake Champlain, and the Finger Lakes of New York (Smith and Tibbles, 1980; Nettles et al., 2001; Marsden et al., 2003; Eshenroder, 2014) and are the focus of an international, integrated pest management program. These parasitic fish have devastated commercially and recreationally important native fish populations, including Lake Trout (*Salvelinus namaycush*) and coregonids. Control of sea lamprey in these systems is coordinated by the Great Lakes Fishery Commission (GLFC) and occurs through cooperation with state, provincial, and federal partners in the United States and Canada (Christie and Goddard, 2003). As part of the integrated control effort, the GLFC and partners are continuously seeking additional control measures to further suppress Great Lakes sea lamprey populations (GLFC, 2011).

The sea lamprey life cycle is complex and presents several points where control efforts might be effectively deployed (Johnson, 1987), some of which are currently targeted by control efforts. Sea lamprey adults migrate into tributaries in spring to spawn and then die; their larvae (ammocoetes) remain relatively sedentary in the stream substrate for three to seven years (Applegate, 1950; Youson et al., 1993). Following metamorphosis from filter-feeding larvae into parasitic juveniles, sea lamprey migrate from natal stream habitats to the lake environment (Applegate, 1961; Potter, 1980) where they parasitize fish for 12 to 20 months before returning to streams to mature and spawn (Kitchell and Breck, 1980). Suppression of Great Lakes sea lamprey populations is currently achieved by targeting the larval life stage and adult migratory period, using lampricides and barriers, respectively. Expanding control opportunities to additional life stages (i.e., downstream migrating juveniles) could bolster an already effective, integrated program. Trapping or killing newly metamorphosed, downstream migrants (transformers) would remove individuals immediately prior to inflicting damage on the fishery (Johnson et al., 2014). Further, reducing the number of transformers that leave tributaries would also reduce the number of individuals that eventually return to streams as adults to reproduce (Swink and Johnson, 2014; Johnson et al., 2016). Unfortunately, a paucity of research on the downstream migration (Katopodis et al., 1994) has resulted in limited understanding of behavior while undertaking downstream movement.

Downstream migration for Laurentian Great Lakes sea lamprey typically begins in October and continues through May; however, large migration pulses associated with fall and spring flood events account for most of the downstream movement (Applegate and Brynildson, 1952; Manion and Smith, 1978). Similar patterns have been observed for downstream movement of anadromous sea lamprey (Silva et al., 2012) as well as Pacific lamprey (*Entosphenus tridentatus*; Moser et al., 2015).

* Corresponding author.
*E-mail address:* smiehls@usgs.gov. (S.M. Miehls).

https://doi.org/10.1016/j.jglr.2018.03.004
0380-1330/Published by Elsevier B.V. on behalf of International Association for Great Lakes Research.

Monitoring of Pacific lamprey impingement at hydropower facilities suggests downstream movements may occur near the substrate (Moser et al., 2015); however, no description of spatial distribution within the stream for sea lamprey transformers has been published. To address this information gap, we documented the distribution of sea lamprey transformers across both stream width and depth within a stream channel and tested the hypothesis that movement of this life stage is spatially random within the stream. We used catches in both drift and fyke nets to determine if distribution varied laterally across the width of the stream, vertically within the stream, and if distribution varied with stream flow.

## Methods

### *Field sites and gear description*

Sea lamprey transformers were collected in Morpion Stream in Notre-Dame-de-Stanbridge, Quebec, Canada and Malletts Creek in Colchester, Vermont, USA. Morpion Stream is a low-gradient tributary to the Pike River, which flows into Missisquoi Bay, Lake Champlain. Malletts Creek is a high-gradient stream that flows into Malletts Bay, Lake Champlain. Both streams have abundant larval habitat and consistently produce high numbers of juvenile sea lamprey due to a ban on use of lampricides. The province of Quebec prohibits the discharge of lampricide into natural waters and Malletts Creek has a population of endangered northern brook lamprey (*Ichthyomyzon fossor*). During 2012, sampling in Morpion Stream took place in a large bend in the stream channel approximately 500 m upstream of the confluence with the Pike River. The stream channel was approximately 8 m wide, and the thalweg was pushed to the right bank midway through the bend (Fig. 1B); upon exiting the bend, flow and depth evened to become relatively uniform from bank to bank (Fig. 1D). During 2013, sampling in Morpion Stream occurred in a long, straight run located immediately upstream of the confluence with the Pike River. The last 400 m upstream of confluence was approximately 8 m wide and channelized,

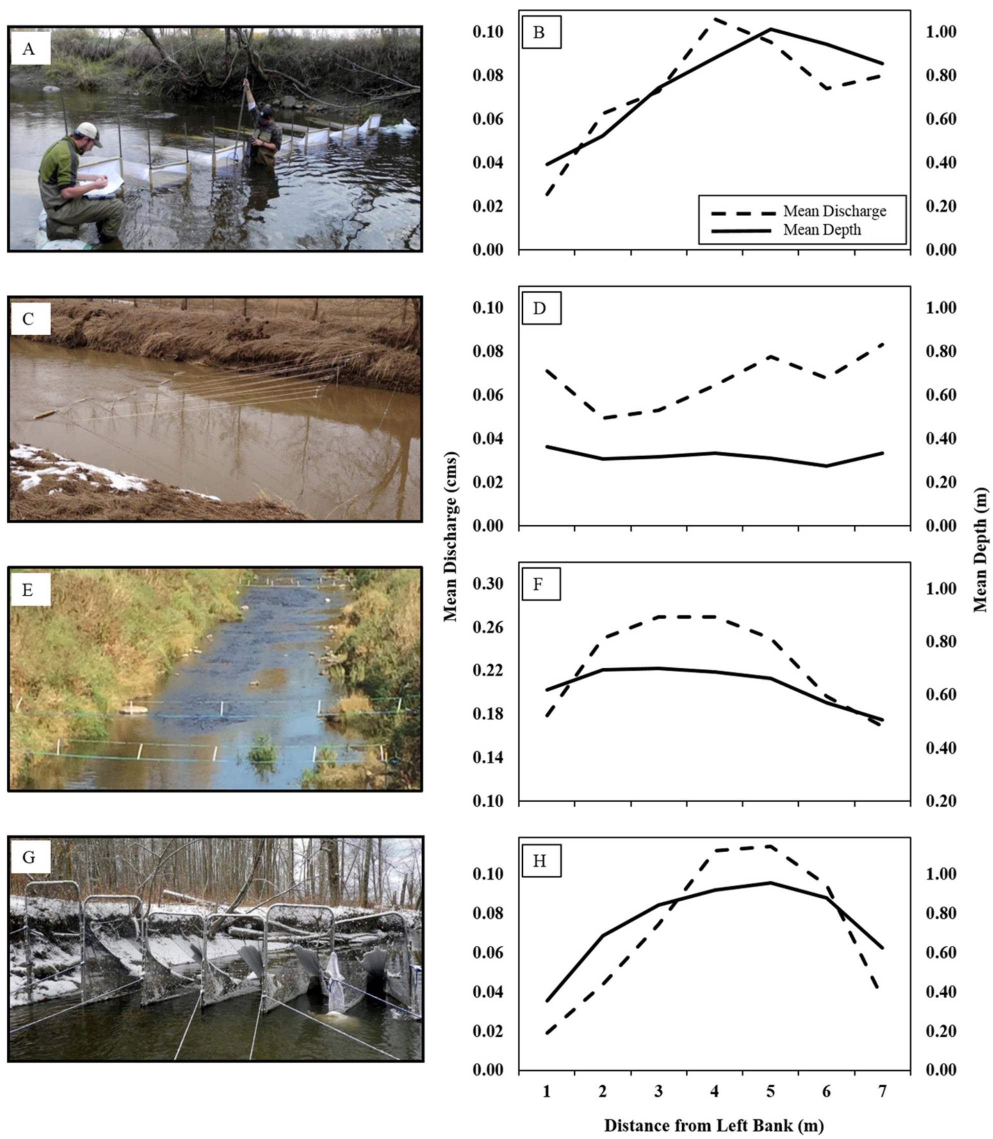


**Fig. 1.** Vertically stacked drift nets mounted on reinforcing steel bar frames used for collecting downstream migrating juvenile sea lamprey from bottom and midwater strata in Morpion Stream, Quebec during Fall 2012 and 2013 (A). Mean discharge and stream depth profile from weekly measurements taken October 17–December 17, 2012 immediately upstream of bottom and midwater sampling nets in Morpion Stream, Quebec (B). Floating drift nets installed on an overhead kingline in Morpion Stream, Quebec during fall 2012 and 2013 used for collection of downstream migrating juvenile sea lamprey from surface strata (C). Mean discharge and stream depth profile from measurements taken weekly October 17–December 17, 2012 immediately upstream of surface sampling nets in Morpion Stream, Quebec (D). Channelized reach of Morpion Stream, Quebec where surface and bottom nets were deployed (E). Mean discharge and stream depth profile from measurements taken at a fixed sampling location in Morpion Stream, Quebec October 21 through November 25, 2013 (F). Fyke net array operated during fall 2012 and 2013 for collection of downstream migrating juvenile sea lamprey in Malletts Creek, VT (G). Mean stream depth and mean water velocity measured weekly Oct 18–Dec 18, 2012 at 1-m intervals laterally from left to right bank across Malletts Creek, VT (H).