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Habitat characteristics of a unionid refuge in the thermal plume of a power plant in western Lake Erie

Nick J. Bryan, Daryl L. Moorhead *, Todd D. Crail

Department of Environmental Sciences, University of Toledo, 2801 West Bancroft St., Toledo OH, USA

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ABSTRACT

We examined habitat characteristics to determine why a rich community of unionid mussels lives in the thermal plume of the Bayshore Power Plant, Oregon Ohio. We expected to find that the power plant reduced the density and viability of dreissenid veligers and that the depth and organic matter content of sediments in the thermal outflow were greatest near the plant. Water temperature averaged 3.8 ± 1.5 °C warmer at the plant's outflow than intake, and the ratio of live:dead veligers was significantly lower at the outflow than intake on most dates ($P \leq 0.05$). A laboratory experiment confirmed that heating water comparable to passing through the power plant significantly reduced veliger viability ($P \leq 0.01$). However, wind direction affected the differences in veliger density between the intake and outflow ($P \leq 0.01$), with easterly winds (opposing the direction of discharge) increasing the density of veligers at the outflow. Similarly, water temperature declined with distance from the plant, but east winds increased variations in water temperatures. Apparently wind direction facilitates (westerly) or slows (easterly) the discharge of water from the small embayment receiving the power plant's thermal effluent. Particulate organic matter content of the thermal plume varied with wind speed, apparently due to suspension of sediments in this shallow water. Finally, only the coarse (>10 mm) size fraction of the benthic sediments was related to distance from the power plant. Thus the thermal regime of this habitat appears to be the primary explanation for this unionid refuge.

Introduction

Historically, western Lake Erie supported abundant populations of unionids (Nalepa et al., 1996), but their abundances have decreased by 99% since 1960 (Nichols and Smith, 2009). Pollution, habitat alteration, and invasion by dreissenid mussels contributed to this decline (Morang et al., 2011; Schloesser and Nalepa, 1994; Stevens and Neilson, 1989), although dreissenid impacts are probably the best documented (Nalepa et al., 1996; Schloesser and Nalepa, 1994; Schloesser et al., 2006). Nonetheless, robust unionid communities coexist with dreissenids in several shallow (<2 m) refuge habitats (Bowers and de Szalay, 2003; Bowers et al., 2005; Bryan et al., 2013; Crail et al., 2011; McGoldrick et al., 2009; Nichols and Amberg, 1998; Nichols and Wilcox, 1997; Zanatta et al., 2002). If the critical characteristics of these refuges that allow coexistence can be determined, then managers could focus on conserving and even creating habitats to increase unionid populations.

The most favorable habitats for unionids have low dreissenid fouling, stable surface sediment (Allen and Vaughn, 2010; Yeager and Cherry, 1994), and ample food and fish hosts (Strayer, 2008). For dreissenid infestation to be low, the habitat must either have a low influx of dreissenid veligers or conditions that allow unionids to shed dreissenids after attachment. Deep, soft surface sediments in marshes and bays allow unionids to burrow and shed dreissenids by suffocation and dislodgement (Bowers et al., 2005; Nichols and Wilcox, 1997). Predators can also remove dreissenids directly from unionid shells (Bowers et al., 2005). Water level fluctuations can kill dreissenids or cause them to release from unionids when they are exposed to desiccation and temperature extremes (Bowers et al., 2005; Schloesser and Masteller, 1999). Water currents can also keep veliger-laden water from entering habitats and reduce settling (Bowers and de Szalay, 2003; Bryan et al., 2013; McGoldrick et al., 2009). A combination of these factors inhibiting dreissenid infestation may operate in shallow habitats of western Lake Erie.

A unionid refuge was recently discovered in the thermal plume of the Bayshore Power Plant, located on the south shore of Maumee Bay in Oregon, Ohio (Bryan et al., 2013; Crail et al., 2011). The plant removes water from the Maumee River as it enters Lake Erie and discharges warmer water into a small bay created by an island built of sediments dredged from the Toledo shipping channel (Ager, 2009). This habitat contains a diverse community of unionids with much higher densities ($7.16\ m^{-2}$) than reported for other refuges (0.01 to $0.09\ m^{-2}$; Bowers and de Szalay, 2003; McGoldrick et al., 2009; Crail et al., 2011). Bryan et al. (2013) found that both densities and sizes of individual unionids were greater and that infestation by dreissenids was lower inside the

* Corresponding author. Tel.: +1 419 530 2017; fax: +1 419 530 4421.

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plume than at nearby sites located outside the plume. They also found greater amounts of coarse (>2 mm) substrate and organic matter content in underlying lakebed clay sediment nearer the plant than farther away. Bryan et al. (2013) speculated that the higher temperature and flow rate of the thermal discharge from the power plant would inhibit dreissenid infestation and that sediment characteristics near the plant would provide favorable habitat for unionids.

The present study was designed to empirically test possible mechanisms affecting unionid and dreissenid densities within the refuge described by Bryan et al. (2013). In particular, we expected fewer live dreissenid veligers in the thermal plume exiting the plant than in the intake water, due to mortality resulting from passing through the plant. We also expected fewer dreissenid veligers near the plant than at distance because there are relatively few dreissenids in the lower Maumee River, the source of cooling water. We also expected warmer water temperatures, higher particulate organic matter (POM) concentrations in water (potential food source; Nichols and Garling, 1999), higher organic matter content in sediments (potential food source; Raikow and Hamilton, 2001), and greater coarse size (>2 mm) sediment mass in the plume near the plant than far from the plant.

Methods

Study area

Our study was conducted in Maumee Bay, within 500 m of the southern shoreline of Lake Erie. Water samples were taken from the intake canal of First Energy's Bayshore Power Plant and within the thermal plume exiting the plant (Fig. 1). Sediment samples were also taken along a transect extending 2.5 km east from the plant outflow.

Dreissenid veligers

Four, 1 L water samples were collected from the shore at the plant intake and outflow, and from the shore at the Bayshore Park (2 km east of the plant) on five dates (6 June to 15 August, 2012). A plankton net (60 μm mesh) was used to concentrate each sample to 140 ml. Dreissenid veligers were counted in three, 1 to 4 ml aliquots (depending on veliger density) from each concentrated sample. They were counted using a dissecting microscope with cross-polarized light. The average of the three aliquots was used as the veliger density of the sample for statistical analyses.

Four, 10 m plankton tows (60 μm mesh, 0.2 m diameter, ca. 1260 L water filtered) were taken from the shore at the same three locations on four dates (6 June to 26 July). Concentrated samples (140 ml) were held at 25 °C in a laboratory for 24 h. Two, 3 ml aliquots were then taken from each sample and the first 30 veligers in each aliquot were identified as being alive or dead by visual assessment using a dissecting microscope with cross-polarized light, i.e., physically intact, movement, no discoloration due to decay (Horvath and Crane, 2010). Ratios of live:dead veligers were calculated for each aliquot and the average of the two aliquots was used as the live:dead ratio of the sample for statistical analyses.

On 24 June we simulated the heating and turbulence experienced by veligers passing through the power plant in a laboratory experiment. Plankton tows were taken from shore at Bayshore Park (2 km east of the plant) to obtain 2 L of concentrated veligers that were unaffected by heat of the power plant discharge. Veligers were allowed one hour to adjust to room temperature (25 °C) and 70 ml samples were transferred to conical (250 ml) flasks. Each flask was then subjected to (1) heat, (2) turbulence, (3) heat with turbulence, or (4) control (N = 5 for each treatment).

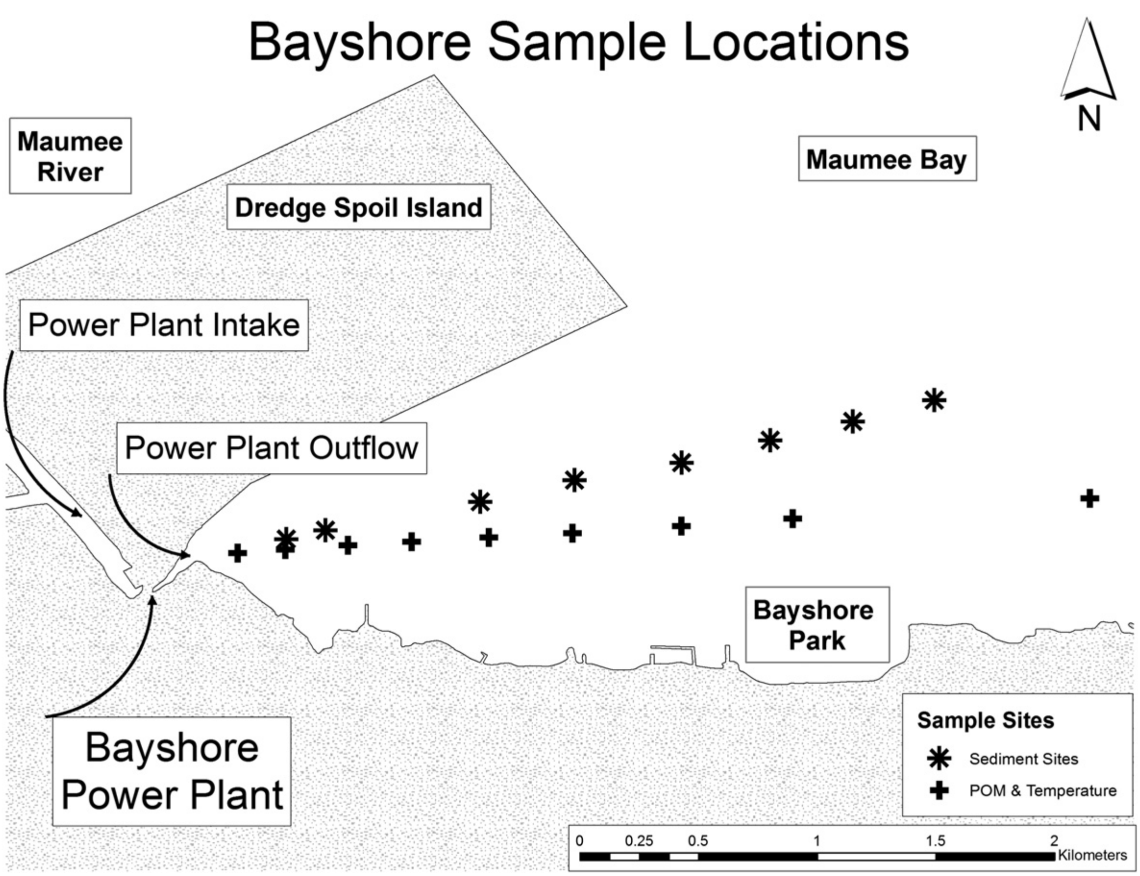

Fig. 1. Sampling locations for particulate organic matter (POM) and water temperature (crosses), and sediment cores (asterisks), along the south shore of Lake Erie at Oregon, Ohio, over 6 June to 26 September, 2012.