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Characteristics of a refuge for native freshwater mussels (Bivalvia: Unionidae) in Lake St. Clair

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ABSTRACT

The Lake St. Clair delta (~100 km^2) provides an important refuge for native freshwater mussels (Unionidae) wherein 22 of the ~35 historical species co-occur with invasive dreissenids. A total of 1875 live unionids representing 22 species were found during snorkeling surveys of 32 shallow (~1 m) sites throughout the delta. Richness and density of unionids and zebra mussel infestation rates varied among sites from 3 to 13 unionid species, 0.02 to 0.12 unionids/m^2, and <1 to 35 zebra mussels/unionid, respectively. Zebra mussel infestation of unionids in the delta appears to be mitigated by dominant offshore currents, which limit densities of zebra mussel veligers in nearshore compared to offshore waters (13,600 vs. 28,000/m^3, respectively). Glycogen concentrations in the tissues of a common and widespread species in the delta (*Lampsilis siliquoidea*) suggest that zebra mussels may be adversely affecting physiological condition of unionids in a portion of the Lake St. Clair delta. Physiological condition and community structure of unionids within the delta may also be influenced by differences in food quantity and quality resulting from the uneven distribution of water flowing from the St. Clair River. The delta likely supports the largest living unionid community in the lower Great Lakes and includes several species that have been listed as Endangered or Threatened in Canada and/or the state of Michigan, making it an important refuge for the conservation of native unionids.

Introduction

In the Great Lakes, declines in native unionids due to the impacts of zebra mussels (*Dreissena polymorpha* Pallas, 1771) have been well-documented (e.g., Schloesser and Nalepa 1994, Nalepa et al., 1996, Schloesser et al., 2006). However, several “refuge” sites for unionids have been found in nearshore wetland habitats of Lake Erie where zebra mussels are present, but at low densities. A viable community of 21 species was found in Metzger Marsh along the south shore of Lake Erie in 1996 (Nichols and Wilcox, 1997), and a community of 15 species was found in nearby Crane Creek Marsh in 2001 (Bowers and de Szalay 2004). Thompson Bay, the outer harbor of Presque Isle Bay, supports a smaller community of only nine species, and annual monitoring between 1992 and 2006 suggests that the community is stable (E.C. Masteller, Pennsylvania State University. pers. comm. 2008). The locations, characteristics, and ultimate significance of these refuges are of considerable interest for unionid conservation.

Zanatta et al. (2002) discovered an important refuge for unionids in the Lake St. Clair delta, where 22 of ~35 historical species were found alive between 1999 and 2001. This refuge falls mainly within the territory of the Walpole Island First Nation. Eight of the species found are designated as Endangered or Threatened in Canada and/or Michigan and a ninth species, the Northern Riffleshell (*Epioblasma torulosa rangiana* Lea, 1838), is listed as Endangered in the US, Canada and Michigan (COSEWIC, 2007a; Michigan DNR, 2007; U.S. Fish and Wildlife Service 2007). Densities of unionids in the Lake St. Clair delta are low, ranging from 0.03 to 0.07 unionids/m^2 (Zanatta et al. 2002), compared to an average density of 2 unionids/m^2 reported for offshore waters of Lake St. Clair before the zebra mussel invasion in 1986 (Nalepa and Gauvin 1988). However, the Lake St. Clair refuge is much larger than any of the other refuge sites discovered to date in

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Lake Erie (~100 km^2 vs. 1 to 3 km^2) and, as such, it sustains some of the largest remaining populations of unionids in the lower Great Lakes. For example, the estimated size of the *Villosa iris* (Lea, 1829) population in the delta is >190,000 individuals (COSEWIC, 2006).

Infestation rates of zebra mussels on unionids in the Lake St. Clair delta are variable and generally higher than those found in other refugia in Lake Erie. Average rates (# zebra mussels/unionid) were <1 in Metzger Marsh (Nichols and Amberg 1999), zero in Thompson Bay (Schloesser and Masteller 1999) and 4 in Crane Creek Marsh (Bowers and de Szalay 2004), whereas average infestation rates in the delta ranged from 3 to 47 (Zanatta et al. 2002). In Metzger Marsh, the limited infestation rates are likely due to the presence of soft sediments, which allow unionids to burrow, thereby smothering any attached zebra mussels (Nichols and Wilcox 1997). The low infestation rates in Thompson Bay and Crane Creek Marsh are attributed to water-level fluctuations that expose zebra mussels and cause them to either release voluntarily from unionids or perish (Schloesser and Masteller 1999, Bowers and de Szalay 2005). Zanatta et al. (2002) speculated that low infestation rates of unionids in the nearshore waters of Lake St. Clair delta, relative to those recorded in the open waters of the lake (Gillis and Mackie 1994), may be the result of fluctuations in the number of zebra mussel veligers reaching and settling in the shallow areas of the delta due to variations in wind direction, currents and water levels.

Although the zebra mussel infestation rates reported in the delta by Zanatta et al. (2002) are well below the lethal threshold of 100 zebra mussels/unionid reported by Ricciardi et al. (1995) and Schloesser et al. (1996), a subsequent study determined that significant declines in unionid density can occur when the mean infestation rate exceeds 10 zebra mussels/unionid (Ricciardi et al., 1996). Unionid mortality in some systems has also been attributed to increased competition for food resources by zebra mussels (Strayer and Smith, 1996). Assessing the effects of low levels of zebra mussel infestation on the physiological condition of unionids may help to determine if these remnant Great Lakes populations are stable.

Effects of stressors, like zebra mussels, may adversely affect the relative condition of unionids at levels that are lower than those that cause mortality. Thus, researchers often look to sublethal measures, such as those influencing physiology, biochemistry and reproduction, because these measures may be predictive of future mortality. Glycogen is the principal storage form of carbohydrates in many aquatic invertebrates (Stetten and Stetten 1960, De Zwaan and Zandee 1972, Hummel et al. 1989) and has been used as an indicator of physiological condition in unionids. For example, glycogen has been used as an indicator of stress resulting from emersion (Greseth et al. 2003), parasitic infestations (Jokela et al. 1993), relocation and quarantine (Patterson et al. 1997, Naimo et al. 1998), and zebra mussel infestation (Haag et al. 1993, Hallac and Marsden 2000).

Changes in total lipid and/or individual fatty acid concentrations in organisms can reveal broad scale changes in ecosystem function (Hebert et al. 2006, 2008). Fatty acids have been successfully used as trophic markers (reviewed in Dalsgaard et al., 2003). Because many fatty acids found in the diet are conserved within the tissues of consumers they have seen widespread use as biomarkers of feeding both in the short (e.g. Brett et al. 2006; Iverson in press) and long term (e.g. Hebert et al. 2008). Traditional methods for determining diet (e.g., gut content analyses, behavioral studies) are time consuming, labor intensive and generally do not integrate the effects of feeding temporally and/or spatially. Fatty acids are helpful in this respect because they integrate the effects of feeding over time. They have also been extensively used as indices of condition in a wide range of aquatic organisms (Arts and Wainman 1999, Schlechtriem et al. 2008) and, occasionally, in marine mussels (Hellou and Law 2003, Alkanani et al. 2007). Although total lipid content has been used to assess the condition of unionids (Haag et al. 1993), using specific fatty acids in such contexts has not been done before.

The Walpole Island First Nation and Environment Canada's Water Science and Technology Directorate formed a 3-year partnership in 2003 to develop and implement an action plan to conserve and recover unionid communities of the Lake St. Clair delta. The objectives were to: a) document the composition of unionid communities throughout the shallow (<1.5 m) waters of the Lake St. Clair delta, b) determine the spatial distribution and abundance of zebra mussels veligers, c) evaluate the effects of water currents on the distribution of zebra mussel veligers and, d) examine variation in the physiological condition of unionids across the delta as they relate to the rate of zebra mussel infestation.

Methods

Study area

The Lake St. Clair delta is located at the mouth of the St. Clair River where it enters the northeast end of Lake St. Clair (Fig. 1). The delta is bisected by the Canada/US border between the Province of Ontario and the State of Michigan. The Canadian portion of the delta falls mainly within the territory of the Walpole Island First Nation (WIFN), which contains >12,000 ha of wetlands and is one of the largest wetland complexes in the Great Lakes Basin (The Nature Conservancy 1995). More than 50 plant and animal species listed as Canadian Species at Risk occur on the lands and in the waters of the WIFN (Bowles 2005). In contrast, the US portion of the delta is highly urbanized with hardened shorelines (Jaworski and Raphael 1976). Average annual discharge of the St. Clair River is ~5000 m^3/s (Lake St. Clair Canadian Watershed Coordination Council 2005). The flow of water from the river is divided into three main channels in the upper part of the delta and a number of secondary channels in the lower delta. The eastern (Canadian) section of Lake St. Clair receives only 8% of the inflow from the St. Clair River (Environment Canada, et al. 1994). A dredged navigation channel crosses the lake along the international border, and water masses on either side of the channel rarely mix (Lake St. Clair Canadian Watershed Coordination Council 2005). The southeastern (Canadian) water mass is warmer and more productive, whereas the northwestern (US) water mass, which receives most of its water from Lake Huron, is cooler and less productive (Leach 1980).

Assessment of unionid communities in the delta

Thirty two sites were surveyed for unionids, 18 quantitatively and 14 semi-quantitatively (Fig. 1). Surveys were conducted at depths of 0.5 to 1.5 m where previous surveys showed most live unionids would be found (Zanatta et al. 2002). Individual sites were selected for survey using several criteria. First, quantitative sampling was repeated at nine sites that had been previously surveyed by Zanatta et al. (2002). The other 9 quantitative sites and the 14 semi-quantitative sites were selected to distribute sampling effort across the shallow bays of the delta and in a few instances were based on aboriginal knowledge of areas known to support unionids. Only locations where live unionids were observed were selected for intensive quantitative surveys. Given that sites were not chosen randomly, these data should not be viewed as representative of the entire delta. Quantitative surveys were conducted from July 21 to August 8, 2003 at nine sites in Canadian waters (Sites 1–7, 15 and 18) and nine sites in US waters (Sites 8–14 and 16–17) using the following "circle-plot" sampling technique devised by Zanatta et al. (2002). At each site, three transects spaced ~25 m apart perpendicular to shore were searched by a two-person team consisting of a snorkeler and a helper. The snorkeler swam until a live unionid was encountered, at which point the helper pounded an iron stake into the substrate next to the unionid; a U-bolt attached to a 4.55 m length of rope was slipped over the stake, and the snorkeler held the other end of the rope and extended it to its maximum length. The snorkeler then swam around the stake in circles