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Fish Assemblages and Environmental Variables Associated with Gobiids in Nearshore Areas of the Lower Great Lakes

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ABSTRACT. *We investigated which fish species and environmental variables were associated with the invasive round goby (Neogobius melanostomus) and tubenose goby (Proterorhinus marmoratus) in nearshore Canadian waters of the Huron-Erie corridor of the lower Great Lakes. We measured a suite of environmental variables and used triplicate beach seine samples to collect fishes in summer 2006. Thirty sites were sampled in the day and a subset (n = 14) at night. Of 1,955 individuals caught in daytime samples, round goby (21.0 %), spottail shiner (17.3%) and emerald shiner (14.2%) were most abundant. Of 1,521 individuals collected at night, the most abundant species were round goby (42.3%) and emerald shiner (24.1%). Tubenose gobies represented 1% and 1.7% of all individuals caught in the day and night, respectively. Rarefaction analysis showed that overall species richness was greater in the day than night. Significantly more emerald shiner (P = 0.017), rock bass (P = 0.046) and round goby (P = 0.035) were caught at night than in the day; more logperch were caught in the day than at night (P = 0.042). Round gobies were positively associated with water temperatures up to 24°, but there was no relationship between round goby abundance and warmer temperatures. There were too few tubenose goby captured to determine their statistical association with environmental factors; however, tubenose gobies were found only where round gobies were collected. Round goby and tubenose goby were associated with yellow perch and rock bass. The benthic round goby was the most abundant species, whereas other abundant species were pelagic, schooling fishes that occupied a habitat distinct from round goby.*

INDEX WORDS: *Environmental variables, fish assemblages, round goby, tubenose goby.*

INTRODUCTION

In freshwater ecosystems, invasive species are a significant threat to biodiversity (Sala *et al.* 2000). Although the Laurentian Great Lakes is not a global hot spot for invasive species (Drake and Lodge 2004), the region has a large number of aquatic invasive species (at least 182 species at present; Ricciardi 2006). Two invasive gobiid species, the round goby (*Neogobius melanostomus*) and tubenose goby (*Proterorhinus marmoratus*), were originally reported in the St. Clair River in 1990 (Crossman *et al.* 1992, Jude *et al.* 1992). Of all non-indigenous species within the Great Lakes, the round goby represents the fastest spreading vertebrate. Five years after the round goby was first reported, it had spread to all five Great Lakes (Charlebois *et al.* 1997). Nighttime vertical migration of round goby larvae and ballast transport likely accounted for the rapid dispersal of the species (Hensler and Jude 2007). Round goby are very abundant with an estimated population size in western Lake Erie alone in 2002 of 9.9 billion (Johnson *et al.* 2005a).

In contrast, the smaller tubenose goby is found infrequently in the Great Lakes. Its North American distribution is localized, occurring mainly in the

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Huron-Erie Corridor (H-EC) from the St. Clair River, Lake St. Clair, and the Detroit River to locations along the north shore of the western basin of Lake Erie (Leslie *et al.* 2002). Tubenose gobies also occur in shoreline areas of South Bass (2001, 2007), Middle Bass (2007), and North Bass (2007) islands in the western basin of Lake Erie (J. Tallman personal communication). In April 2001, a tubenose goby was caught in a trawl net by U.S. Geological Survey biologists in the Duluth Superior Harbor, western Lake Superior (Blust 2003). Since then, tubenose gobies and round gobies are commonly reported in regular monitoring programs in the Duluth-Superior Estuary Harbor region of western Lake Superior (Greg Peterson, U.S. EPA, Duluth and Dennis Pratt, Wisconsin DNR—Superior, personal communication). This jump dispersal by tubenose goby from the lower Great Lakes to Lake Superior can be explained by ship transport (Charlebois *et al.* 1997, Hensler and Jude 2007).

Despite differing distribution patterns of the round goby and tubenose goby in North American, both species are widespread in their native range. Specifically, the round goby is distributed widely throughout the Ponto-Caspian region and beyond, occurring in freshwater (lakes, reservoirs, and rivers), estuarine, and coastal habitats (Pinchuk *et al.* 2003). The tubenose goby also is widespread in its native Ponto-Caspian region and beyond, occurring in less saline estuaries, lakes, rivers, and wetlands (Pinchuk *et al.* 2004). Although the round goby has spread to the Gulf of Gdansk and Baltic Sea, the tubenose has not yet invaded that region (Pinchuk *et al.* 2004).

The success of the round goby is likely due to its broad diet (crustaceans, soft-bodied macroinvertebrates, dreissenids), aggressiveness, high fecundity, repetitive annual spawns, and male parental care (Corkum *et al.* 2004). Although tubenose goby may eat mussels in their native range (Pinchuk *et al.* 2004), their diet in the Great Lakes is mainly amphipods, crustaceans, and insects (French and Jude 2001). Drake (2007) showed that parental care (not fecundity or brain size, a correlate of cognitive ability) was associated with establishment success in introduced species. It is unclear why tubenose gobies have played a seemingly minor role as an invasive species. Because males of both round goby (MacInnis and Corkum 2000) and tubenose goby (Ahnelt *et al.* 1998) guard embryos, parental care does not explain the differential success of these species. In other gobiids, habitat use and preference (macrophytes) account for the differentiation in success (Humphries and Potter 1993).

In this study, we determined which fishes were associated with round goby and tubenose goby and which environmental variables accounted for their distribution in the H-EC, the area of their original colonization in the Great Lakes. We also wondered if these species were day or night active (as determined by numbers captured in beach seines) and if this activity was a function of their body size. We expected small (vs. large) gobies to be more active at night because predation risk is perceived to be greater during the day (cf. Clark and Levy 1988).

METHODS

Sampling and Study Sites

This field study was designed to examine fish assemblages and environmental factors associated with round goby and tubenose goby in the H-EC. Ten sites were sampled in each of the following locations: Lake St. Clair (including a part of the St. Clair River), Detroit River, and Lake Erie (Fig. 1).

In summer (June–August) 2006, we collected fishes by beach seining (triplicate samples) along the Canadian H-EC shoreline. The seine net was 9.1 m in length and 1.8 m deep (mesh size: 6.4 mm) with a bag 1.8 m long × 1.8 m deep (mesh size: 3.2 mm). The seine was deployed perpendicular to shore for its entire length and then swept back in an arc to the shore. We selected sites that could be accessed safely. Because sampling sites were separated by at least one tributary, we assumed that the sites represented independent samples. Daytime sites (n = 30) were sampled between 0830 and 2100 hours. Nighttime sites (n = 14) were selected from a subset of corresponding daytime sites (Fig. 1) and were sampled within 48 h of the date of the new moon between 2105 and 0545 hours. Of the 14 sites, four were sampled along Lake Erie, four along Detroit River, four along Lake St. Clair, and two along St. Clair River. Nighttime samples were taken during the new moon because moonlight is known to affect fish dispersal (Wickham 1973).

Twelve environmental variables measured at each site were aquatic macrophytes (present/absent; simple/complex), depth and maximum distance from shore where fishes were seined, elevation (GPS device, Magellan®), floodplain vegetation, riparian vegetation, shoreline type, slope, substrate, turbidity, water temperature, and water body. If present, aquatic vegetation was scored as simple or complex (Lapointe *et al.* 2007) because the morphological