Final Report
for
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Quantifying Round Goby Dispersal Mechanisms: Impacts on Mitigation Efforts

Jeffrey G. Miner
Department of Biological Sciences
Bowling Green State University
Bowling Green, OH 34403
(419) 372-8330
jminer@bgnet.bgsu.edu

John R. Farver
Department of Geology
Bowling Green State University
Bowling Green, OH 34403

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Project Focus:

One of the primary foci of the Lake Erie Commission is to foster research that will lead to a limiting of future invasive species introductions and the spreading of these exotic species in the Lake Erie basin. Additionally, abatement strategies to eradicate or reduce populations of targeted nuisance ANS in Lake Erie need to be developed. The primary goal of our proposed research was to identify specific life history characteristics (dispersal mechanisms) of round gobies *Neogobius melanostomus*, which could be used in abatement/mitigation programs for minimizing further spread of this nuisance species.

Another important focus for the Lake Erie Commission is to address water quality issues and sediment contaminant conditions in Lake Erie. By consuming primarily dreissenid mussels (zebra and quagga mussels), round gobies may act as a conduit for the transfer of contaminants into the food chain, and thus to humans. However, little is known about the extent to which round goby adults migrate among locations and thus their ability to translocate contaminants from known regions of contamination (e.g., harbors) to other locations via direct seasonal migration. Our research into juvenile and adult round goby migration patterns was designed to provide managers with baseline biological data , so that they can understand the extent to which round gobies could disperse into new habitats (invasion) and potentially transfer contaminants (away from harbors).

Project Summary:

Early Life Stage Round Gobies

We proposed to determine the major mechanisms of round goby dispersal, which we suggested were via nocturnal planktonic stage for early juvenile round gobies or through seasonal migration of adults. To address migration ability through the nocturnal plankton, we proposed to conduct diel ichthyoplankton sampling off South Bass Island to quantify this use of the plankton and then couple it with water current data (ours) and GLFS water current estimates to predict dispersal capability of this life stage.

Adult Round Gobies

From trawling data collected by the Ohio Division of Wildlife, the extent to which adult round gobies migrate seasonally is unclear. Thus, we proposed to use a new technique to quantify this migration. Collecting adult round gobies in six harbors and six open water locations in the Central and Western Basins of Lake Erie, we used chemical analyses of the fishes' otolith (a set of bones in head of each fish) to determine if we can detect unique chemical signatures for these harbors and regions (similar to DNA fingerprinting in concept). Using this chemical analysis (laser ablation mass spectroscopy at the U of Windsor) we proposed to determine if round gobies have been in these specific harbors and regions throughout their lives or if there is consistent seasonal migration. If harbor/regional differences could be detected, then in future research we planned to identify round gobies from specific 'hot spots' for toxic substances and determine the extent to which these round gobies migrate from the source and distribute the toxic substances.

Project Results:

Early Life Stage Round Gobies

Through a master's thesis (attached), Todd Hayden was able to determine the abundance of early-life stage round gobies using the water column during nocturnal periods. While no round gobies were found in the pelagic during the day, densities greater than 50 individuals per $100m^3$ of water were detected during nocturnal periods (Figure 1 of thesis). Most of these fish were early juveniles less than 10 mm in total length (Figure 2) and they were feeding on zooplankton in the water column (Figure 3). These results suggest that the primary mechanism for dispersal of invasive round gobies may occur during night-time ballasting when ships could take on thousands of metric tonnes of water with accompanying round gobies. Given that propagule size (number of invaders introduced at one time) is an important determinant of invading success, ballasting of early life stage round gobies seems the logical mechanism for this introduction.

The research focus on young round goby dispersal is important because millions of dollars are being directed (U.S. Army Corps, Great Lakes Protection Fund, U.S. Fish and Wildlife) to develop techniques for limiting dispersal of round gobies both between waterways in the U.S. and via transoceanic ballast water. However, we believe that most of this effort is being directed at the wrong life stage and therefore will be ineffective. Additionally, monitoring efforts may be switched to look for nocturnal drifting round gobies rather than the intensive sampling that has been conducted for the relatively few adults in an expanding population.

Adult Round Gobies

Following collection of round gobies from six harbors and open water sites throughout western and central Lake Erie (in cooperation with the Ohio DNR) in fall of 2002, otoliths were removed from the fish and prepared for analysis of microchemistry concentrations. Using laser ablation inductively coupled plasma mass spectroscopy (LA-ICPMS at the University of Windsor). Chemical concentration of elements in otoliths were obtained from the core (primordia, formed during early life stages) to the margin (time when the fish was collected). Due to the need for calibration of the mass spectrometer (May through November 2003), otoliths could not be processed until early December 2003. These samples are currently being analyzed. However, we have analyzed the few otoliths that were processed before May 2003. As an example, we present a figure showing the elememtal concentrations of two fish, one from the open water region of the Central Basin and one fish from the Grand River Harbor (Figure 4). The abrupt shift in the compositions of the otolith from the Grand River fish suggests that this fish changed the crystalline form of its otolith from aragonite to vaterite, which can be a sign of physiological stress. It is possible that this fish migrated into the Grand River Harbor and experienced stressful conditions causing this shift. Analyzing the

chemical signatures from the otoliths of the remaining 120 round gobes will help clarify the causes of these differences.

The value of using otolith microchemistry to determine habitat use by benthic round goby adults is two-fold. The Lake Erie Protection & Restoration Plan calls for the improvement of Ohio's harbors and tributaries through the removal of hazardous sediments, but many of the sediments have moved out into the near shore areas of Lake Erie. Round gobies, being benthic fishes that feed on benthic invertebrates (including zebra mussels) can accumulate these hazardous materials and then migrate to distribute these contaminants. This study will provide the preliminary data to show the extent to which we can identify the migration of these fishes. A second strategic objective of the LEP&R Plan is to limit the spread of exotic species. Unless we know the relative dispersal ability of adult versus early juvenile round gobies (above), we will not be in a strong position to institute mitigation strategies.

Project Dissemination:

The results from this study have been presented to the Ohio Fish and Wildlife Conference (2003) and the Midwest Fish and Wildlife Conference (2003), the Midwest Ecology and Evolution meeting (2003) and at the Ohio Academy of Sciences meeting (2004).

Three manuscripts are in preparation for this study:

Hayden, T and J.G. Miner. In prep. Nocturnal vertical migration of early juvenile round gobies: New mechanism for dispersal and invasion. Canadian Journal of Fisheries and Aquatic Sciences 19 pages, 1 table, 3 figures (Submission date: April 2004)

Hayden, T., J.G. Miner, and J. Farver. In prep. Habitat use and migration of round gobies in Lake Erie: initial evidence from otolith microchemistry. To be submitted to Journal of Great Lakes Research in 2004.

Hickey, H., J.G. Miner, T. Hayden, and J. Farver. In prep. Diel vertical migration of zooplankton in Lake Erie: potential effects on nutrient allocation between the pelagic and benthos. To be submitted to Limnology and Oceanography (June 2004).

Project Benefits:

Work on this project has been useful in obtaining preliminary data necessary to secure funding from the Ohio Sea Grant Program (for 2005-2007) to study otolith microchemistry and migration patterns of white bass, an important sport fish in Lake Erie. Additional collaborations and proposals will be submitted to NSF, USDA, and other federal and state agencies.

With the otolith microchemistry data we will be looking to determine if this approach can be used to detect the presence of heavy metals (e.g., Zn, Cr,) or stressful environmnetal conditions for fishes and other aquatic life in the harbors of Lake Erie.

One master's thesis was completed through this project (Todd Hayden). In addition, an undergraduate student is completing an independent project in which she (Heather Hickey) is using the data collected from the project to study diel vertical migration of zooplankton.

Budget:

	Proposed	Expended
Personnel	$5,301	$5,904
Supplies	$600	$1,154
Travel	$890	$533
Other (Instrument Use)	$2,300	$1,500
Indirect	$909	$909
Total	$10,000	$10,00

Expenses were slightly higher than expected for personnel (a graduate student assistantship). The costs for supplies and instrument use were tightly coupled (supplies to prepare the material for analysis), so the sum of these two expenses was similar to proposed amount. Travel was slightly less than expected because we did not have to stay overnight at Windsor to get the work accomplished.

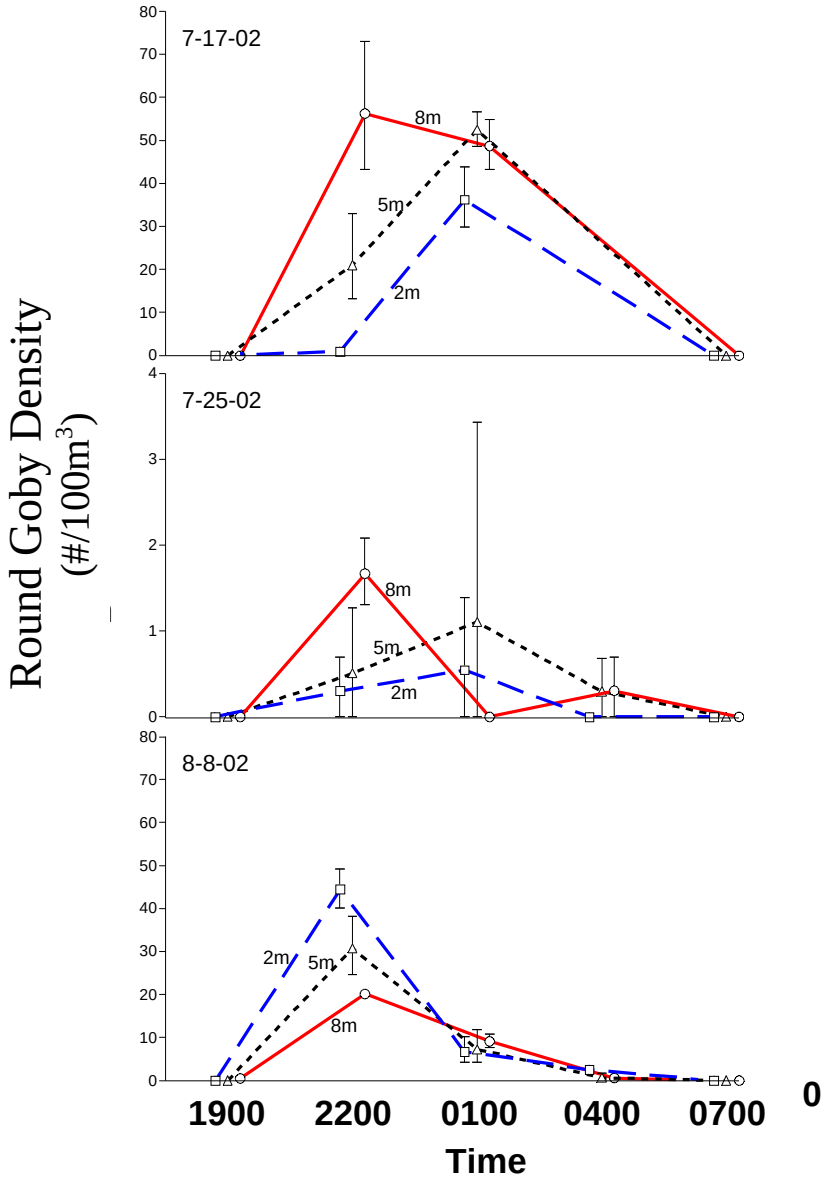


Figure. 1. Pelagic juvenile round goby density for three sampling dates in western Lake Erie. Long-dashed lines indicate density at 2-m depth; short-dashed lines = 5-m depth; solid-lines = 8-m depth. Fish were collected with an ichthyoplankton net at 2m, 5m, and 8m depth in water ≥10-m deep. Geometric means (and standard errors) are based on two replicate samples ($\log_{10}$ (density + 1) transformation) and back transformed for ease of interpretation. Grey area denotes samples collected during nocturnal period. Note: no data collected on 7/18/02 at 0400h and difference in scale for 7/25/02.

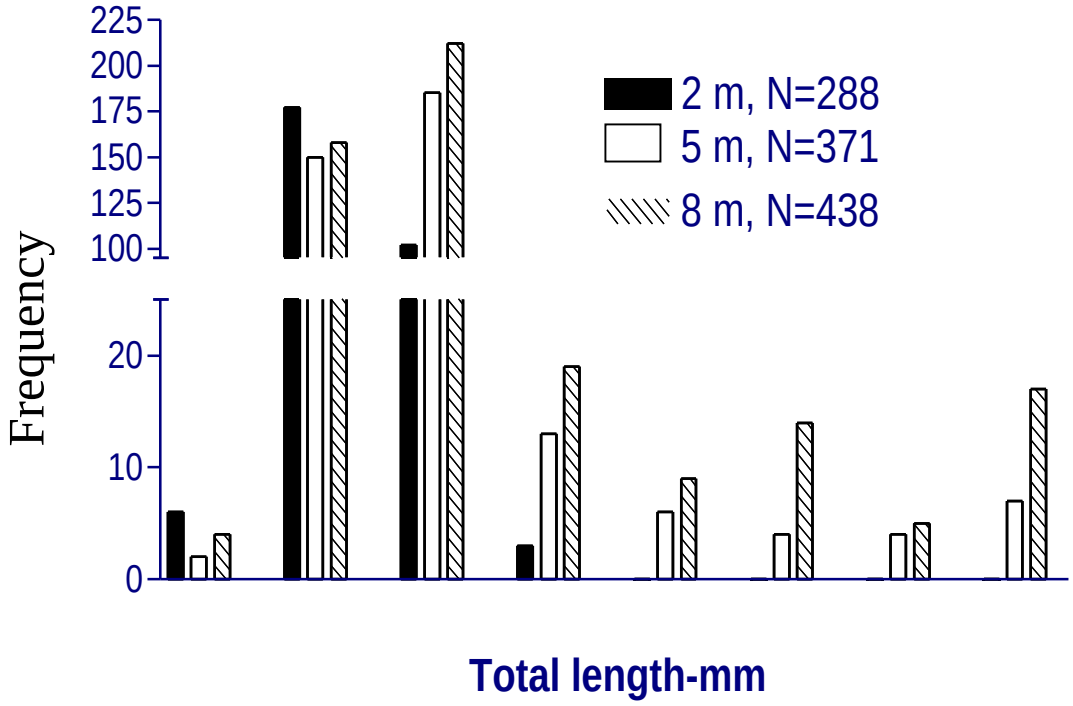
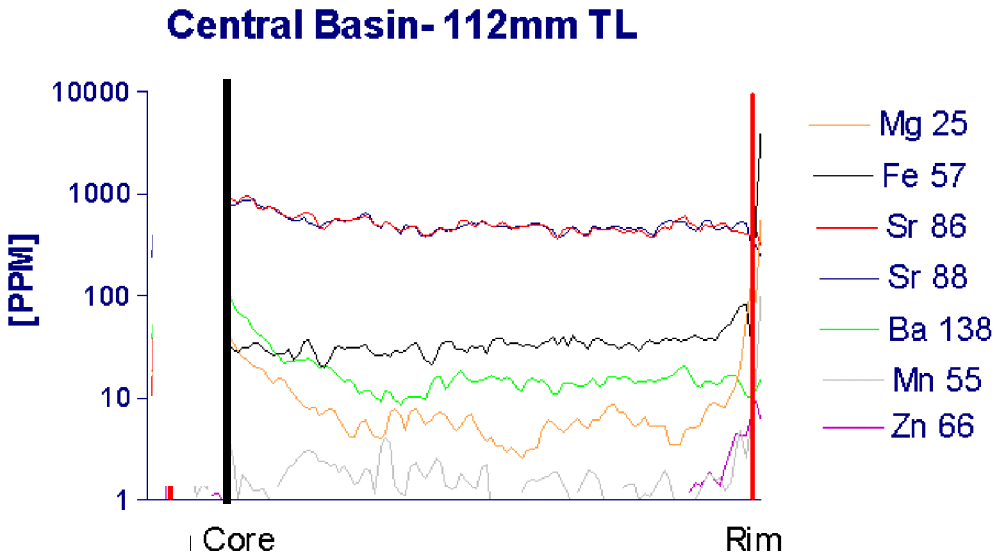


Figure. 2. Length-frequency distribution by collection depth of pelagic juvenile round gobies in western Lake Erie (≥10-m deep). Chi-square analysis consisted of 1-mm length classes and the class ≥13-mm TL. N=1097. Fish collected over three sample dates were pooled.

Figure 3 – This figure could not be inserted here because it was generated on a platform incompatible with Microsoft products. The pdf of Figure 3 occurs separately.



Round Goby Otolith Microchemistry

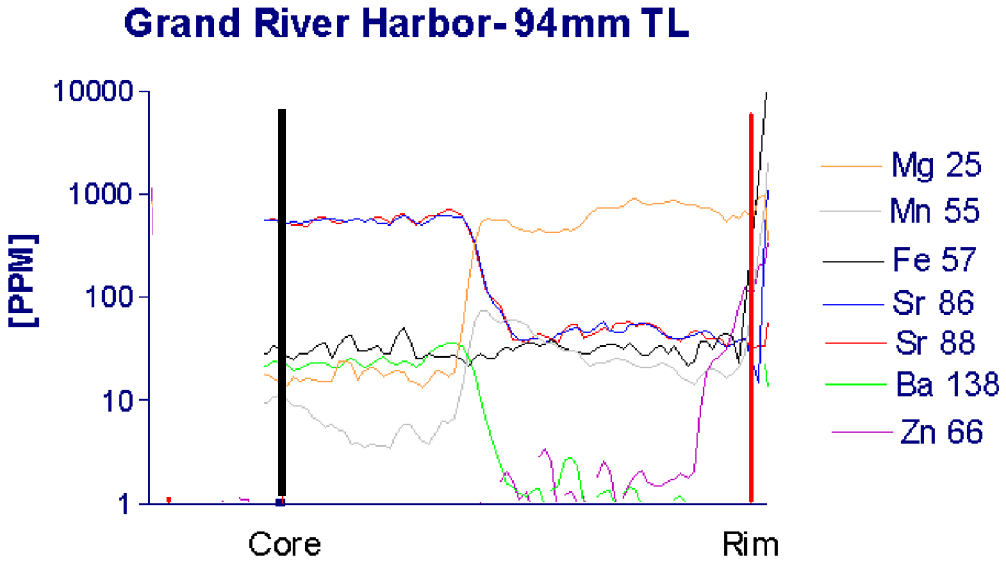


Figure 4. Concentrations of elemental isotopes (ppm) from two round gobies collected in Lake Erie, 2002. The top analysis comes from a fish collected in the Central Basin of Lake Erie in open water habitat while he bottom figure is for a round goby from the Grand River Harbor. In the open water fish, otolith concentrations of strontium (86 and 88), barium (138), iron (57), and magnesium (25) remained relatively constant throughout the fish's life, suggesting that the fish remained in water of consistent chemical composition. The otolith from the round goby found in the Grand River Harbor demonstrates a chemical composition as consistent as that found for the other fish until a point in time when magnesium (25) and manganese (55) increase by 15 fold, and at the same time, strontium isotopes (86 and 88) and barium (138) decline by 10 fold.