NEW YORK STATE WATER RESOURCES INSTITUTE

Department of Biological and Environmental Engineering

230 Riley-Robb Hall, Cornell University
Ithaca, NY 14853-5701
http://wri.cals.cornell.edu

Tel: (607) 254-7163
Fax: (607) 255-4449
Email: nyswri@cornell.edu

Invasive round goby as a water quality assessment tool: bioindicators of contaminants in Northeastern U.S. inland waters

Suresh A. Sethi, Department of Natural Resources, Cornell University, suresh.sethi@cornell.edu

with

Randy Jackson, Lars Rudstam, and Katie Fiorella, Cornell University

Lisa Cleckner and Trevor Massey, Finger Lakes Institute

A round goby, *Neogobius melanostomus*, taken from Cayuga Lake, NY.

Abstract

After first being recorded in Lake Erie and Lake Ontario in the early 1990s, the invasive fish Round goby (*Neogobious melanostomus*) is rapidly expanding across New York inland waterbodies and is advancing towards the Hudson River system and Atlantic Ocean. Where introduced, round goby quickly reach high biomass. As predators, round goby foraging behavior potentially exposes them to high contaminant loads, consuming benthic invertebrates and filter feeding invasive mussels. Because round goby are widely spread throughout habitats in invaded systems, they are easy to catch, and their range is expanding, they may provide an indicator reflective of contaminant levels in inland

waterbodies, providing spatially extensive bioindicators of water quality. Here, we assessed total mercury concentration in 52 round gobies sampled among 5 lakes in NY. Goby contaminant levels were consistent within waterbody, but varied significantly among waterbodies with mean concentrations ranging from 16.5 – 77.9 THg ng/g wet weight. Round goby contaminant levels were associated with lake-wide total mercury contaminant levels, with Onondaga Lake fish having substantially higher total mercury loads. These results suggest round goby may reflect waterbody contaminant loads and serve as potential bioindicators of contaminants in invaded waterbodies.

Three Summary Points of Interest

- **Round goby are spreading rapidly from the Great Lakes to inland waters through connected waterways.**
- **We assayed 52 round goby among 5 NY lakes for total mercury concentration and found contaminant concentrations varied widely among populations, ranging from 10 – 140 THg ng/g (wet weight) among individuals.**
- **As a benthic feeding fish, round goby concentration levels were associated with patterns in lake-wide mercury contamination, indicating this species may provide an indicator of total mercury loads in waterbodies.**

Keywords
Mercury, fish consumption, food webs, contaminants, mussels, freshwaters

Invasive round goby as a water quality assessment tool: bioindicators of contaminants in Northeastern U.S. inland waters

Introduction

Invasive round goby continue to spread rapidly inland from the Great Lakes (Kornis et al. 2012). This invader is likely to spread into the Hudson River system through the Erie Canal, reaching many NY waterbodies along the way and potentially ultimately arriving at the Atlantic Ocean. Round goby in infested systems can quickly reach high biomass, with field observations indicating typical goby densities of 5 fish/m2 and up to 70 fish/m2 (Andres et al. forthcoming). Once established, round goby become part of the foodweb, and thus part of the contaminant cycle (Ng and Gray 2009). Mercury and organochloride contaminant loads are a concern for water quality, and bioaccumulation to harvested game fish can present health risks for fish consumers. As predators, round goby exhibit behaviors which could expose them to high toxin loads. First, they are bottom-dwelling fish and forage on invertebrate infauna in sediments, where contaminants such as mercury and organochlorides can accumulate. Second, they also prey on filter feeding invasive *Dreissenid* mussels (quagga and zebra) which, by straining the water of plankton also have potential to accumulate contaminants. Thus, they may make sensitive bioindicators for trace contaminants in benthic habitats. In this project we assessed mercury contamination levels in round goby across a suite of five waterbodies in NY to investigate mercury uptake dynamics and the potential for round goby to reflect contaminant loads in invaded systems. Results from this work provide initial empirical evidence demonstrating a positive relationship between environmental levels of mercury contamination in waterbodies and associated round goby mercury concentration, suggesting potential for gobies to serve as a bioindicator of contaminant loading in aquatic systems.

Results & Discussion

We collected and assayed a total of 52 round goby across a range of sizes and weights taken from 5 infested NY waterbodies: Cayuga Lake, Lake Erie, Lake Ontario, Oneida Lake, and Onondaga Lake. Onondaga Lake is known to harbor high mercury contaminant loads owing to previous industrial activity in the area. Mercury concentrations in lake bottom sediments peaked as high as >100 THg mg/kg sediment (1 mg/kg = 1000 ng/g) in the 1970s (Klein and Jacobs 1995), with contemporary levels in surface sediments averaging 1340 THg ng/g sediment (EPA 2015). In contrast, published information on total mercury concentrations in sediments in other sampled waterbodies or nearby lakes are considerably lower. Sediment core analysis in Cayuga Lake indicates total mercury concentrations in lake sediments range between 40 - 180 THg ng/g (Geiser et al. 2015). Core analysis at Seneca Lake (1998; nearby to Cayuga Lake) indicates total mercury concentrations of 130 THg ng/g in superficial sediments (Callinan 2001), whereas Lepak et al. (2015) find that contemporary total mercury concentrations in nearshore habitats for Lakes Erie and Ontario were 174 and 327 THg ng/g, respectively (median values). Finally, the most recent environmental concentrations of total mercury in Oneida Lake are from 1994 and 1996 (CNYPB 2003), ranging from 140-170 THg ng/g in superficial sediments. We found total mercury concentration in round goby tracked total mercury loads among the waterbodies in which fish were sampled, with total mercury concentrations in Onondaga round goby highest (Table 1; Figure1).

Table 1. Total mercury concentrations in round goby (*Neogobius melanostomus*) sampled from New York waterbodies in 2018, and published values of surficial total mercury contaminants in lake sediments.

	Hg in round goby		Hg in sediments	
Waterbody	Mean total Hg (ng/g)	S.E.	Surficial sediment total Hg (ng/g)	Ref.
Onondaga Lake	77.9	29.9	1340	EPA 2015
Cayuga Lake	27.2	10.4	40-180	Geiser et al. 2015
Lake Ontario	21.8	4.2	327	Lepak et al. 2015
Lake Erie	16.5	3.5	174	Lepak et al. 2015
Oneida Lake	11.4	2.6	140-170	CNYPB 2003

This material is based upon work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G16AP00073

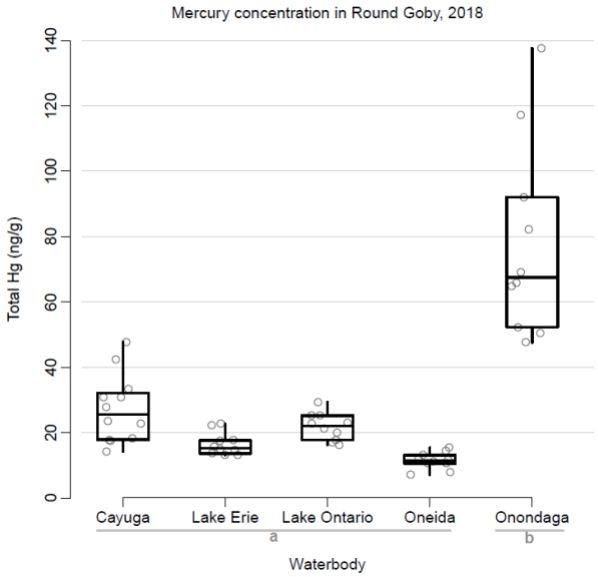

Figure 1. Boxplots of total mercury concentration in round goby (*Neogobius melanostomus*) sampled in New York waterbodies in 2018. ANOVA analysis identifies Onondaga lake (a) fish as statistically significantly different ($F=77.0$; d.f. = 5, 47; $p < 0.001$) from all other lakes (b).

Policy Implications

Our results indicate that as bottom-foraging animals, round goby appear to track total mercury loads in relative proportion to contaminant loads in lakes. Furthermore, while these animals may have potential as bioindicators of total mercury loads in lakes, interestingly they carry low mercury concentrations themselves, consistent with recent understanding about bioaccumulation in benthic foraging fish (e.g. Karimi et al. 2016) and possibly reflecting high growth potential of round goby (e.g. Lee and Johnson 2005). The implications of this are that top predator game fish which switch to round goby prey may have lower contaminant loads, than for diets based on pelagic prey, *all things the same*. We highlight a need for further investigation of the role of round goby in mercury bioaccumulation for top predator game fish as a top knowledge need in understanding the interactions between environmental contaminant loads and public health as impacted by fish consumption in NY waters as this persistent invader continues to spread throughout the Northeast region of the U.S.

Methods

We collected round goby (*Neogobius melanostomus*) in nearshore environments using stick seines. Collection efforts were spread across multiple waterbodies and targeted a range of goby sizes. Sampling was synchronized and occurred approximately over July/August of 2018. Tissue samples from collected goby were processed at the Finger Lakes Institute in Geneva, NY, for age, size, and total mercury content. Goby contaminant levels were compared using classical inferential statistics to assess variation among total Hg concentrations among individuals within lakes, and among waterbodies.

Outreach Comments

Our results were communicated to NY State Department of Environmental Conservation lake mangers in Region 7 and Region 8 through in person meetings. In addition, results from this research will join with efforts to assess contaminant levels in other freshwater prey fish towards a large collaborative effort to use bioenergetics modeling to understand the role of round goby in contaminants cycling in game fish (PI SA Sethi, Cornell University). This work includes collaboration across NY DEC, Finger Lakes Institute, Cornell, SUNY-ESF, SUNY-Brockport, and USGS, catalyzing important cross-institutional collaboration to assess contaminants cycling in NY State's inland freshwaters.

Publications/Presentations

The following presentations included results or data associated with this work:

Sethi SA (2019) "Fisheries research perspectives for Northeast waters," invited presentation, Tunison Research Labs, Cortland, NY.

Sethi SA, et al. (2018) "Characterizing the ecological niche of invasive round goby in inland lakes," presentation at International Association for Great Lakes Research, Toronto, Canada.

Lepak J, Sethi SA, Rice A, et al. (2018) "The role of invasive Round Goby in the Great Lakes basin," presentation at NY Chapter American Fisheries Society, Cooperstown, NY.

This material is based upon work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G16AP00073

Additional final reports related to water resource research are available at http://wri.cals.cornell.edu/news/research-reports

References

Andres K, Sethi SA, Lepak J et al. Lake morphology may mediate the potential for trophic impacts from invasive round goby. Freshwater Biology, In review.

Callinan CW. 2001. Water quality study of the Finger Lakes: part B: sediment core investigation. NY State Department of Environmental Conservation, Technical Report 78.

Central New York Planning and Development Board (CNYPB) 2003. Oneida Lake state of the lake and watershed report. CNYPB Report, April 2003, Syracuse NY.

U.S. Environmental Protection Agency (EPA) 2015. First five-year review report Onondaga Lake bottom subsite of the Onondaga Lake superfund site. U.S. EPA report, September 2015.

Geiser K, Grossnickle P, Curtin TM. 2015. Evaluating potential sources of mercury accumulation in Cayuga Lake, NY (USA) over the past two centuries. 2015 Annual Meeting of the Northeast Division of the Geological Society of America, March 23, 2015.

Karimi R, Chen CY, Folt CL. 2016. Comparing nearshore benthic and pelagic prey as mercury sources to lake fish: the importance of prey quality and mercury content. Science of the Total Environment 565, 211-221.

Klein SM, Jacobs LA. 1995. Distribution of mercury in the sediments of Onondaga Lake, NY. Water, Air, Soil Pollution 80, 1035-1038.

Kornis MS, Mercado-Silva N, Vander Zanden MJ. 2012. Twenty years of invasion: a review of round goby Neogobius melanostomus biology, spread and ecological implications. Journal of Fish Biology, 80, 235-285.

Lee VA, Johnson TB. 2005. Development of a bioenergetics model for Round Goby (*Neogobius melanostomus*). Journal of Great Lakes Research 31, 125-134.

Lepak R, Yin R, Krabbenhoft DP, et al. 2015. Use of stable isotope signatures to determine mercury sources in the Great Lakes. Environmental Science and Technology Letters 2, 335-341.

Ng CA, Gray KA. 2009. Tracking bioaccumulation in aquatic organisms: a dynamic model integrating life history characteristics and environmental change. Ecological Modelling 220, 1266-1273.

Disclaimer

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Geological Survey. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Geological Survey.

This material is based upon work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G16AP00073