Bottom trawl assessment of Lake Ontario's benthic preyfish community, 2021

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Abstract

Since 1978, the Lake Ontario preyfish community survey has provided information on the status and trends of the benthic preyfish community related to Fish Community Objectives that includes understanding preyfish population dynamics and community diversity. Beginning in 2015, the benthic preyfish survey expanded from US-only to incorporate lake-wide sampling sites which increased the survey's spatial coverage, and resumed sampling in eastern US embayments (Black River, Chaumont, Guffin, and Henderson Bays) that were historically sampled during a September bottom trawl survey to index yellow perch from 1978 to 2007. In 2021, the collaborative benthic preyfish survey completed 195 bottom trawl tows across main lake and embayments at depths from 5 to 226 m. New embayment sites at Bay of Quinte, Sodus, and Little Sodus Bay were added to the survey in 2021 to compare fish communities across nearshore sites. In total, the 2021 survey sampled 107,110 fish from 35 species. Round goby (*Neogobius melanostomus*) was the most numerically abundant species comprising 44% of the total catch, followed by deepwater sculpin (*Myoxocephalus thompsonii*), and alewife (*Alosa pseudoharengus*) at 17% and 12%, respectively. Deepwater sculpin accounted for most (402 kg) of the fish biomass sampled during the 2021 survey (total=1,963 kg), followed by common carp (252 kg, *Cyprinus carpio*), white perch (248 kg), and round goby (237 kg). Slimy sculpin (*Cottus cognatus*) biomass was higher in 2021 than in 2020, when spatial coverage was reduced. Deepwater sculpin biomass remained high in 2021 and similar to observations since 2019. White perch biomass (*Morone americana*) in Black River Bay has increased compared to observations from historical surveys. Yellow perch (*Perca flavescens*) accounted for most of the benthic preyfish biomass across the embayments surveyed in 2021 except for the Bay of Quinte and Black River Bay, where white perch accounted for a greater proportion of the fish community biomass.

Introduction

Lake Ontario Fish Community Objectives (herein FCOs) call for maintaining predator-prey balance and for maintaining and restoring pelagic and benthic (bottom–oriented, demersal) preyfish diversity (Stewart et al., 2017). Collaborative bottom trawl surveys have annually assessed Lake Ontario preyfish community status and trends since 1978 to provide information for decision-making relative to those objectives. Here, we summarize recent findings from the fall 2021 Lake Ontario benthic preyfish survey.

During the 1970–1980s, the benthic preyfish community was dominated by slimy sculpin (*Cottus cognatus*), with lesser amounts of trout-perch (*Percopsis omiscomaycus*), johnny darter (*Etheostoma nigrum*), and spottail shiner (*Notropis hudsonius*). Recent bottom trawl surveys have documented a decline in slimy sculpin abundance and an increase in non-native round goby (*Neogobius melanostomus*) beginning in 2005, as well as a resurgence in native deepwater sculpin (*Myoxocephalus thompsonii*), once considered extirpated (O'Malley et al. 2021; Weidel et al. 2017). These large changes in benthic preyfish composition exemplify the importance of monitoring populations and improving survey design to provide the best information possible to track population changes through time. Moreover, Lake Ontario spring and fall preyfish surveys have routinely sampled the same lake areas across different seasons from April to October over multiple years, which allows for quantifying seasonal migrations of fish populations to better understand ecosystem structure and function and how habitats are coupled by different species (Ives et al. 2019; Pennuto et al. 2021).

Bottom trawl surveys also measure the progress of native species restoration. In Lake Ontario, bloater (*Coregonus hoyi*), a native coregonine species that inhabits deep, offshore habitats, was considered extirpated from the lake by the 1980s (Weidel et al. 2022). Since 2012, bloater have been reintroduced through stocking, and bottom trawl recaptures allow for tracking the progress of the restoration program (Holey et al. 2021; Weidel et al. 2022). Beginning in 2015, bloater have been captured in bottom trawl surveys, marking the first time this species has been sampled in Lake Ontario since 1983 (Weidel et al.

2022). Additionally, using similar gear types and trawling at similar times of year to other surveys conducted throughout the Laurentian Great Lakes allows managers to interpret Lake Ontario preyfish dynamics at a basin-wide scale, as well as across different habitats (main lake vs. embayments) and depth strata.

This report describes the status of the Lake Ontario benthic preyfish community, with an emphasis on information addressing the bi-national (Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry [NDMNRF], and New York State Department of Environmental Conservation [NYSDEC]) Lake Ontario Committee's FCOs (Stewart et al. 2017). This research is also guided by U.S. Geological Survey (USGS) Ecosystems Mission Area science strategy that seeks to understand how ecosystems function and provide services, as well as what drives them, and to develop science and tools that inform decision making related to ecosystem management, conservation and restoration (Williams et al., 2013). In addition to presenting long term results from the benthic preyfish survey, we also leverage bottom trawl data from a survey that sampled northeastern Lake Ontario embayments from 1978 to 2007 to describe community changes in these habitats that were added to the benthic preyfish survey in 2015.

Methods

Benthic preyfish survey

From 1978 to 2011, the benthic preyfish survey sampled six to ten transects along the southern shore of Lake Ontario from Olcott to Oswego, NY. Daytime trawls were typically 10 minutes and sampled depths from 8–150 m (26–495 ft). The original survey gear was a Yankee bottom trawl with an 11.8-m (39 ft) headrope and was spread with flat, rectangular, wooden trawl doors (2.1 m x 1 m). The survey typically occurred during October but also included sampling from September to November (Figure 1). Abundant dreissenid (*Dreissena* spp.) mussel catches in the early 2000s led to the survey abandoning the standard trawl and experimenting with a variety of alternate polypropylene bottom trawls and metal trawl doors

(2004-2010). Comparison towing indicated that alternate trawls caught fewer demersal fishes and the alternative trawl doors influenced net morphometry (Weidel and Walsh, 2013). Since 2011, the survey has used the historically standard Yankee trawl and doors, but has reduced tow times to reduce mussel catches. Typical trawl tows in recent years have been 5 minutes, and in nearshore areas or those where mussel catches are high as indicated by the preceding trawl tow, tow times have been reduced to 2.5-4 minutes. Experimental sampling at new transects and in deeper habitats began in 2012. More notably, in 2015, the survey spatial extent was doubled to include Canadian waters and embayment sites in the eastern basin. At that time, the NYSDEC and NDMNRF research vessels joined the survey, which greatly expanded the spatial extent and diversity of habitats surveyed. Time series generated from the benthic preyfish survey from 1978 to present are illustrated in this report. No adjustments are available for data when the alternative trawls were used.

In 2021, a record high number of 195 trawl tows were completed between three research vessels from September 13 to October 15 (Figure 2). Trawl catches were sorted by species, counted, and weighed. Dreissenid mussels were weighed but not counted or identified to species. Subsamples of species in each trawl tow were measured for individual length and weight. Additional samples for growth, diet, reproduction, and genetic analysis were collected for some species.

Trawl effort was historically based on tow time, and abundance indices were reported as number or weight per 10-minute trawl. Area-swept estimates calculated using trawl mensuration sensors and video cameras indicated that trawl effort expressed as area swept differed substantially from tow-time based effort. Trawl results are expressed as biomass densities (kg/ha, kilograms of fish per hectare) and account for depth-based differences in the lake area swept by the trawl (Weidel and Walsh, 2013). Time series are still regarded as biomass indices, rather than absolute densities, because we lack estimates of trawl catchability (proportion of the true density within a surveyed area captured by the trawl). Trawl tows were assigned to a country based on the mid-point of start-end trawl coordinates. Historical trawl tows without coordinates were assigned to a country based on the nearest port (only U.S. waters). Annual area-weighted biomass indices expressed as kg/ha were calculated for U.S waters (1978–2021) and lake-wide (2015–2021) using thirteen 20 m strata (66 ft) within U.S. and Canadian waters (Table 1). Strata not sampled in a given survey year were assumed to be zeroes for each species. The lake-wide index was calculated assuming 52% and 48% area for Canadian and US waters, respectively. Mean and standard error calculations are from Cochrane (1977).

Perch Survey

From 1978 to 2007, fish communities in northeastern embayments of Lake Ontario (Chaumont, Guffin, Black River, and Henderson Bays) were sampled during late September through early October (Figure 1) in an effort to assess yellow perch (*Perca flavescens*) and white perch (*Morone americana*) populations and document long term trends in the fish community of these habitats (O'Gorman and Burnett, 2001). We refer to this dataset as the perch survey for convenience. In our analysis, we pooled observations from Guffin and Chaumount Bay, and simply refer to these as Chaumont Bay given their close proximity to each other in Lake Ontario. Catch protocols were similar to those described above where species were sorted, counted, weighed, and subsamples were measured for length frequency. From 1978 to 1997, sampling was conducted by the USGS R/V Kaho with a 7.9-m headrope bottom trawl, with a 13-mm stretch nylon mesh cod end. Trawl tows occurred during the day and typically lasted for 5 minutes. Site depths were between 6 to 20 m, and approximately 15 sites were sampled each year. In 1996, problems with fouling from large catches of dreissenid mussels led to the adoption of mud rollers in 1997 to reduce fouling. From 1998-2007, the NYSDEC R/V Seth Green continued the sampling using an 18-m, 3N1 bottom trawl at the same locations. For detailed descriptions of trawl gear used in Lake Ontario surveys, see Lantry et al. (2007). In 2015, the R/V Seth Green resumed sampling these sites annually in early October as part of the benthic preyfish survey using a Yankee bottom trawl. The recent expansion of our annual benthic preyfish survey into these historically sampled habitats has created an opportunity to assess long term trends for fall benthic preyfish communities from these embayments.

In addition to the benthic preyfish survey data, we used data from the perch survey to illustrate long term trends in the benthic fish populations of embayments by combining both datasets. In contrast to lake-wide trends which use an area weighted mean, we report mean biomass density for yellow and white perch for the embayments (1978–2021) without weighting by depth strata. We calculated the biomass proportion of benthic preyfish species for each year using the total weight across all trawl sites per embayment. Additionally, we compared 2021 catches among the eastern embayments to new trawl sites that were added to the benthic preyfish survey in 2021 at Little Sodus, Sodus Bay, and Bay of Quinte. These new sites have also been sampled in the spring preyfish bottom trawl survey that uses a 3N1 trawl (Weidel et al. 2021). Because of issues with fouling from sediments in the Bay of Quinte, a 3N1 trawl was used for these sites during the 2021 benthic preyfish survey instead of a Yankee trawl and tow times were reduced to 2.5 minutes.

Results and Discussion

Bloater – Bloater are a benthopelagic species native to Lake Ontario that historically inhabited deep, offshore habitats. While records are sparse, commercial fishery catches suggest the species was historically abundant in Lake Ontario but rare by the 1970s (Christie, 1973). Catches have been sporadically low since restoration stocking began in 2012 but are reasonable based on our power to detect species at low abundance (Weidel et al., 2022). In 2021, no bloater were captured during the benthic preyfish survey, marking the third consecutive year where bloater were absent in fall bottom trawls.

Slimy Sculpin – Slimy sculpin biomass in 2021 continued to be low compared to historical values but was slightly higher on a lake-wide scale than in 2020, when limited sampling occurred (Figure 3). Once the dominant demersal preyfish in Lake Ontario, slimy sculpin declines in the 1990s were attributed to the collapse of their preferred prey, the amphipod *Diporeia* (Owens and Dittman, 2003). The further declines of slimy sculpin that occurred in the mid-2000s appear to be related to round goby. Recent increases in deepwater sculpin may also have negative impacts on slimy sculpin at the deep edge of their depth distribution where the two species overlap (Volkel et al. 2021). Slimy sculpin distribution appears to vary spatially across suitable Lake Ontario depth strata. Trawl sites in Canadian waters, notably at sites south of Pickering and Oshawa, had the highest biomass density among all trawl tows (Figure 4). Slimy sculpin biomass peaks by depth strata were higher at shallower depths (< 120 m) in Canadian waters, whereas higher biomass density in U.S. waters occurred at depths > 120 m (Figure 5).

Deepwater Sculpin – Deepwater sculpin were the second most abundant preyfish in trawl catches during the benthic preyfish survey in 2021 (Table 2). Deepwater sculpin biomass has generally increased from 2010 to 2017 and has been relatively stable since 2019 (Figure 3; 2019–2021 mean lake wide biomass = 2.98 ± 0.28 SD kg/ha).

Round Goby – Round goby was the most abundant preyfish in trawl catches during the 2021 survey (Table 2), although biomass was lower in 2021 compared to 2020 (Figure 2). Estimating round goby abundance using bottom trawls can be complicated by the fish's preference for rocky substrate and seasonal changes in depth distribution (Ray and Corkum, 2001; Pennuto et al., 2021). Round goby are typically concentrated at shallower depths during the survey (Figure 4).

Embayment Catches – Trawl catches at embayment sites sampled in 2021 (Chaumont Bay, Black River Bay, Henderson Bay, Bay of Quinte, Sodus and Little Sodus Bay) continued to represent species that are not common in main lake catches. Since 2015, these habitats, especially Black River Bay, are the only sites where trawls routinely capture trout-perch, darters, and spottail shiner, native species that were once common in main-lake portion of Lake Ontario in the 1970–1990s (Figure 6). Yellow perch accounted for most of the benthic preyfish biomass across the embayments surveyed in 2021 (Figure 6), except for in Black River Bay and Bay of Quinte where white perch constituted a greater proportion of the catch. Time series constructed from combining the yellow perch survey and benthic preyfish survey indicate increases in white perch biomass in Black River Bay (Figure 7).

Acknowledgements

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Table 1. Proportions of Lake Ontario surface area by 20m depth strata that fall within Canadian and U.S. waters. Blank values indicate depths that are not represented in Canadian waters.

Depth bin (m)	Proportional area in Canadian waters	Proportional area in U.S. waters
0-20	0.176	0.128
20-40	0.163	0.100
40-60	0.126	0.075
60-80	0.143	0.057
80-100	0.120	0.049
100-120	0.130	0.058
120-140	0.097	0.091
140-160	0.036	0.123
160-180		0.177
180-200		0.082
200-220		0.050
220-240		0.009
240-243		<0.001

Table 2. Number of fish caught in the fall 2021 benthic preyfish survey. Dreissenid mussel catch (**Dreissena** ***spp.) is represented by weight in kilograms. Values include all Lake Ontario sampling sites, including Canadian waters.***

Common name	Scientific name	Number caught
Round goby	*Neogobius melanostomus*	47,148
Deepwater sculpin	*Myoxocephalus thompsonii*	17,684
Alewife	*Alosa pseudoharengus*	12,356
Rainbow smelt	*Osmerus mordax*	8,170
Emerald shiner	*Notropis atherinoides*	4,363
White perch	*Morone americana*	4,204
Yellow perch	*Perca flavescens*	4,079
Threespine stickleback	*Gasterosteus aculeatus*	3,753
Gizzard shad	*Dorosoma cepedianum*	2,283
Trout-perch	*Percopsis omiscomaycus*	723
Brown bullhead	*Ameiurus nebulosus*	709
Spottail shiner	*Notropis hudsonius*	564
Pumpkinseed	*Lepomis gibbosus*	409
Slimy sculpin	*Cottus cognatus*	357
White sucker	*Catostomus commersonii*	92
Lake trout	*Salvelinus namaycush*	75
Freshwater drum	*Aplodinotus grunniens*	69
Carp	*Cyprinus carpio*	35
Walleye	*Sander vitreus*	27
Quillback	*Carpiodes cyprinus*	23
Logperch	*Percina caprodes*	14
Darters	*Etheostoma* spp.	13
Largemouth bass	*Micropterus salmoides*	10
Bluntnose minnow	*Pimephales notatus*	9
Black crappie	*Pomoxis nigromaculatus*	7
White bass	*Morone chrysops*	6
Cisco	*Coregonus artedi*	5
Bluegill	*Lepomis macrochirus*	5
Smallmouth bass	*Micropterus dolomieu*	5
Lake whitefish	*Coregonus clupeaformis*	4
Rockbass	*Ambloplites rupestris*	4
Lake sturgeon	*Acipenser fulvescens*	2
Northern pike	*Esox lucius*	1
Channel catfish	*Ictalurus punctatus*	1
Brown trout	*Salmo trutta*	1
Dreissenid mussel (kg)	*Dreissena* spp.	4,983

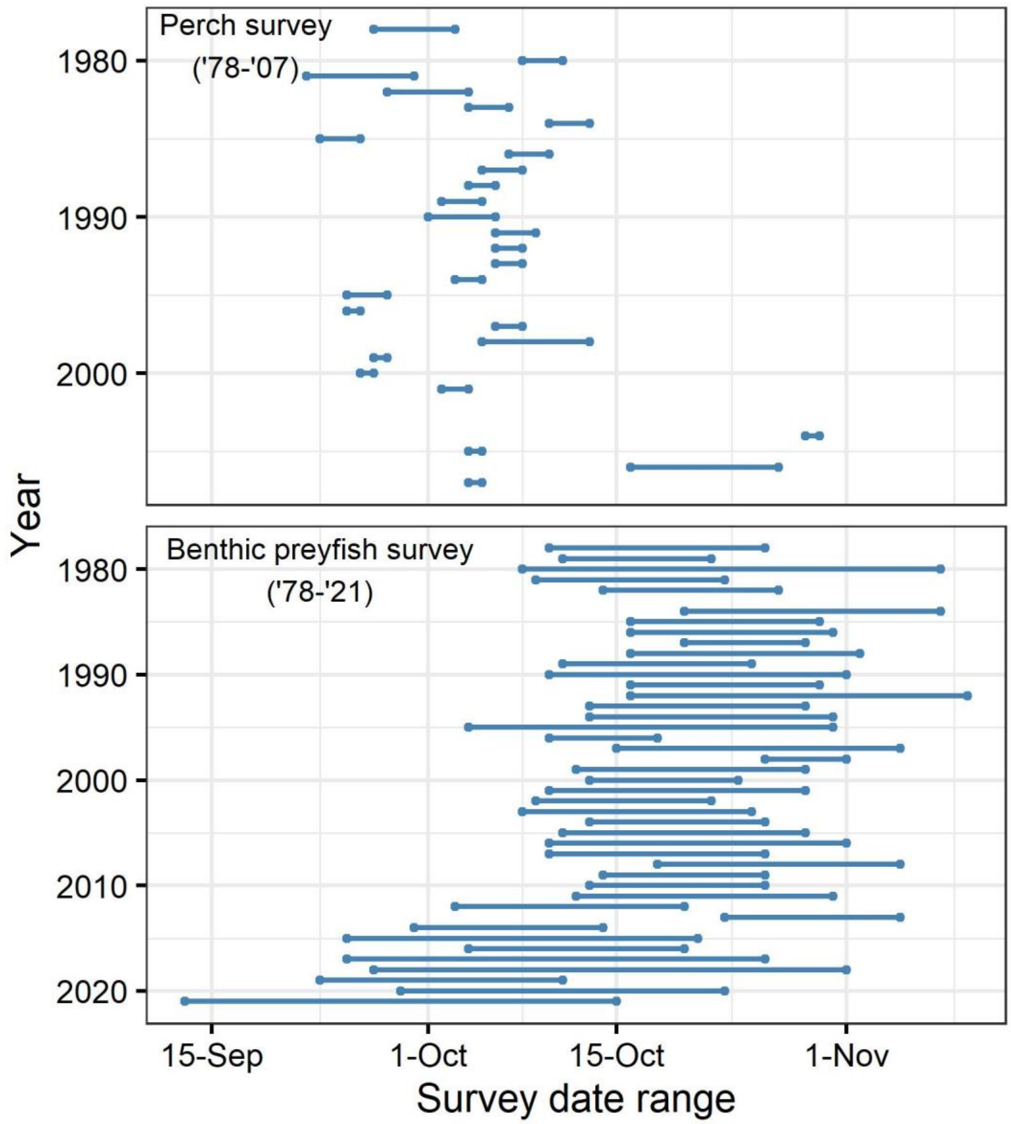

Figure 1. Calendar date range for bottom trawl tows conducted during the yellow perch survey (top panel; 1978–2007) and the benthic preyfish survey (1978–2021).

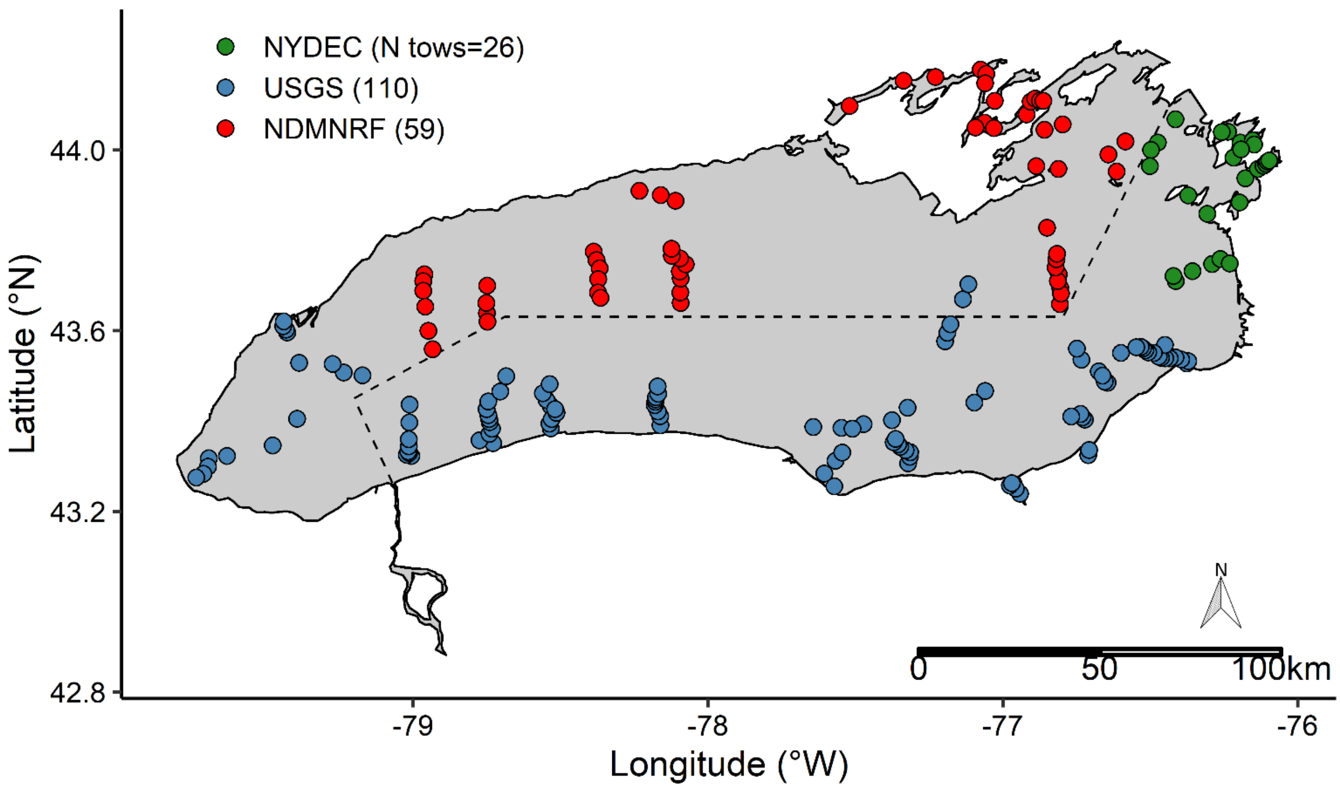

Figure 2. Lake Ontario bottom trawl sites sampled during the 2021 benthic preyfish survey. 195 bottom trawls tows were collectively sampled by the New York Department of Environmental Conservation (NYSDEC) R/V Seth Green, U.S. Geological Survey (USGS) R/V Kaho, and Ontario Ministry of Northern Mines, Natural Resources, and Forestry (NDMNRF) R/V Ontario Explorer during September 13 - October 15. Dashed line represents the U.S.-Canada international boundary.

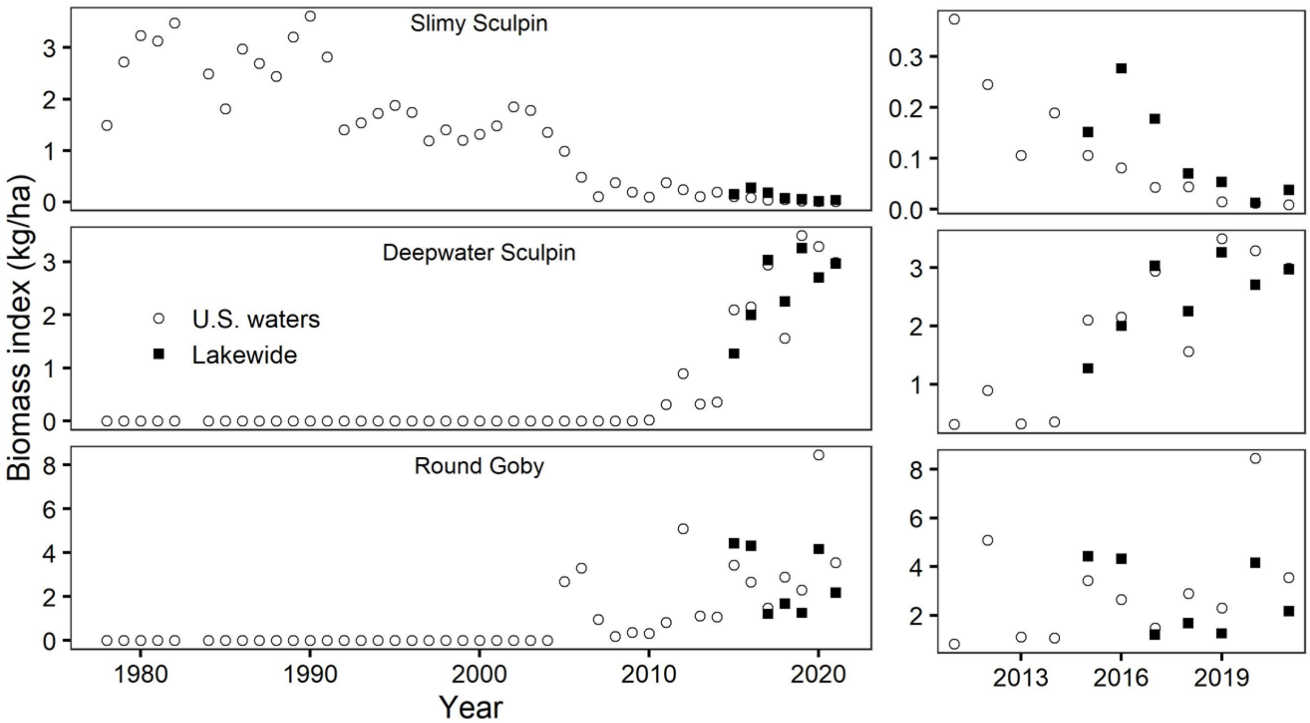

Figure 3. (Left) Area-stratified biomass density (kilograms per hectare) for slimy sculpin, deepwater sculpin, and round goby in the benthic preyfish survey, 1978–2021. Open symbols represent the index for U.S. waters only, and closed squares represent lake-wide values that include trawls from both U.S. and Canadian waters. (Right) A subset of the time series representing only 2011–2021 to illustrate recent trends over the past ten years that may not be apparent when viewing the entire time series. Note the difference in scale for slimy sculpin biomass between the two time periods.

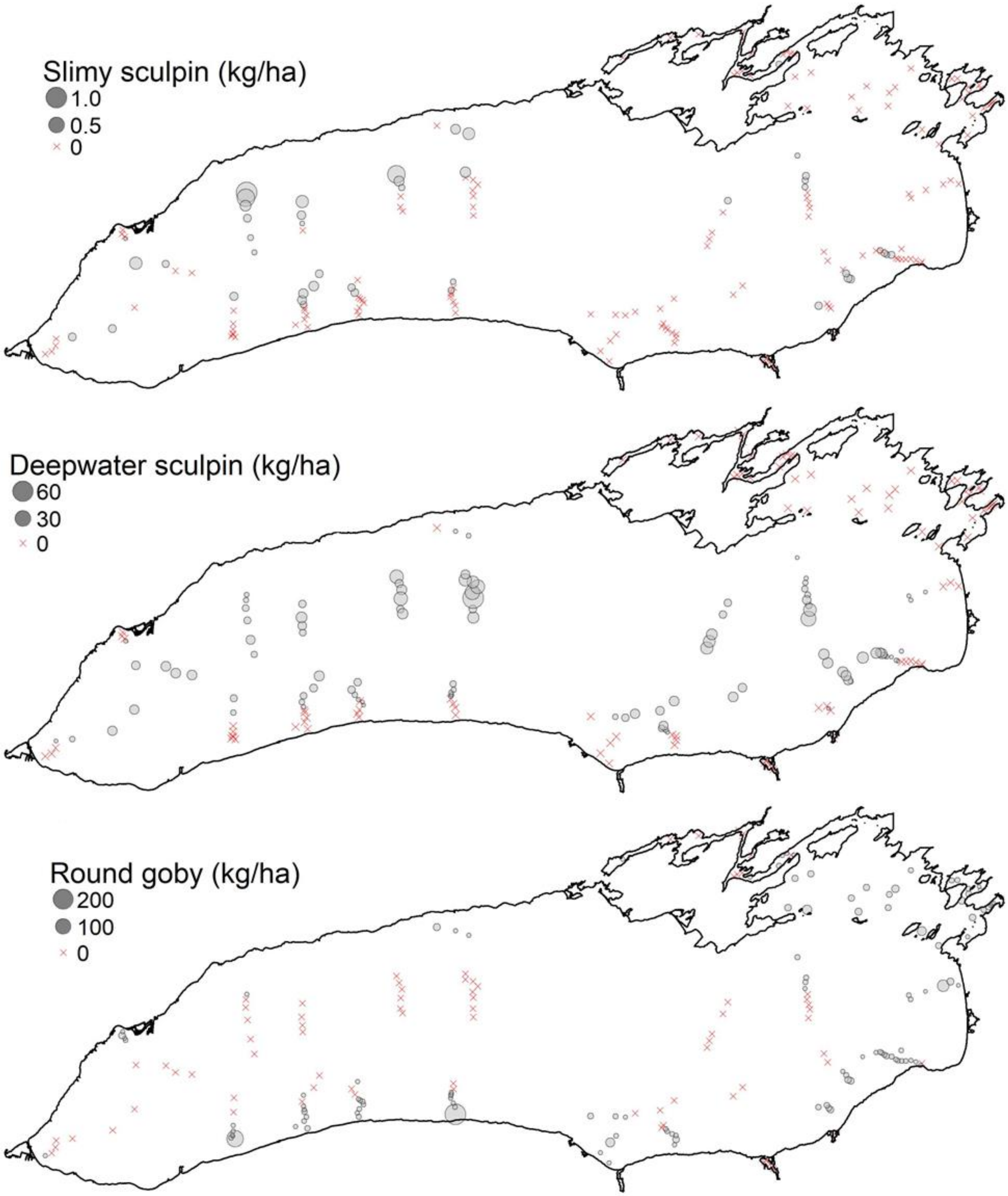

Figure 4. Spatial distribution of biomass density (kg/ha) from individual trawl tows for slimy sculpin, deepwater sculpin, and round goby in Lake Ontario, 2021. Note the difference in biomass scales among maps.

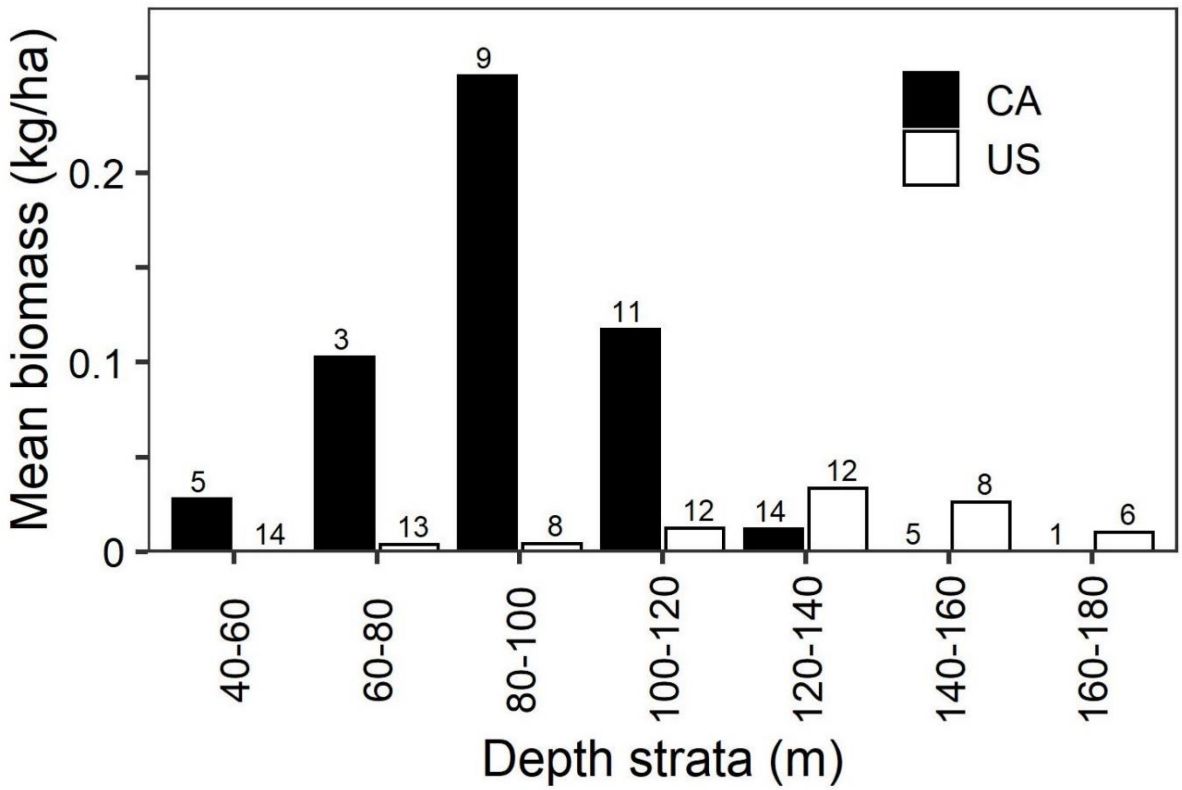

Figure 5. Mean slimy sculpin biomass estimated from bottom trawl tows by depth strata in Canadian (CA) and U.S. (US) waters of Lake Ontario during the 2021 benthic preyfish survey. Numbers above each bar represent the number of trawl tows.

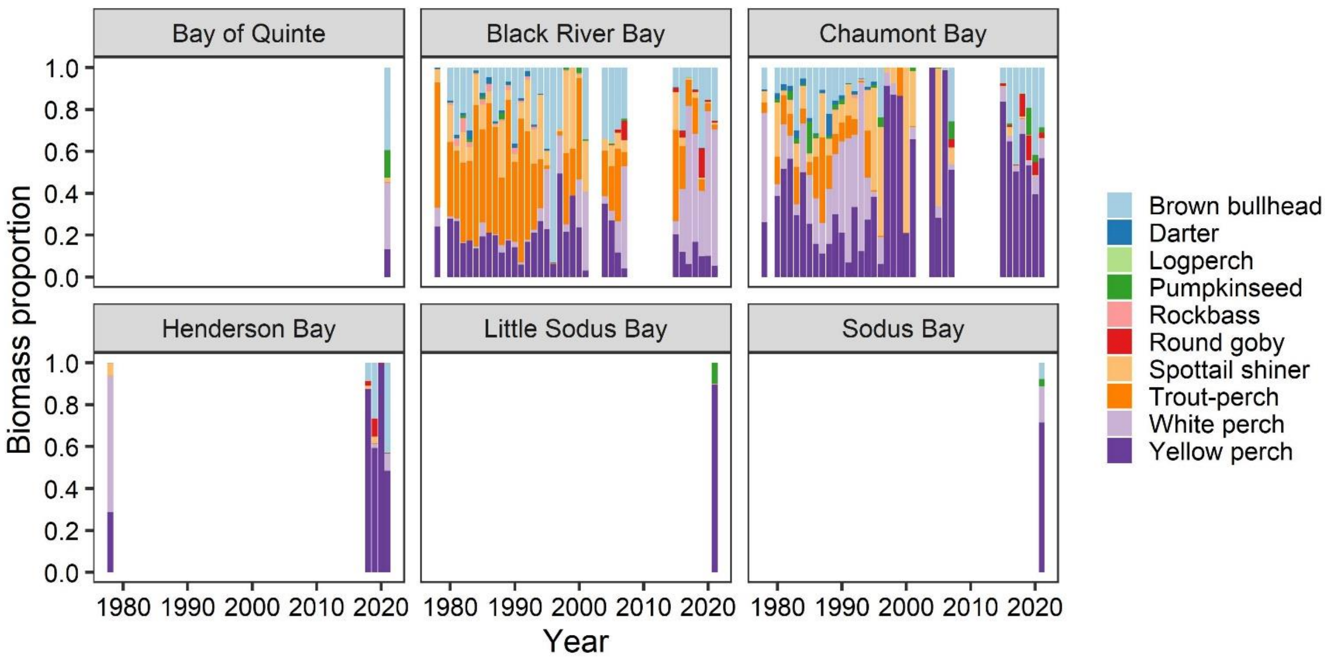

Figure 6. Community composition of benthic preyfish in Lake Ontario embayment catches from the yellow perch survey 1978–2007 (O'Gorman and Burnett 2001), and the benthic preyfish survey 2015–2021.

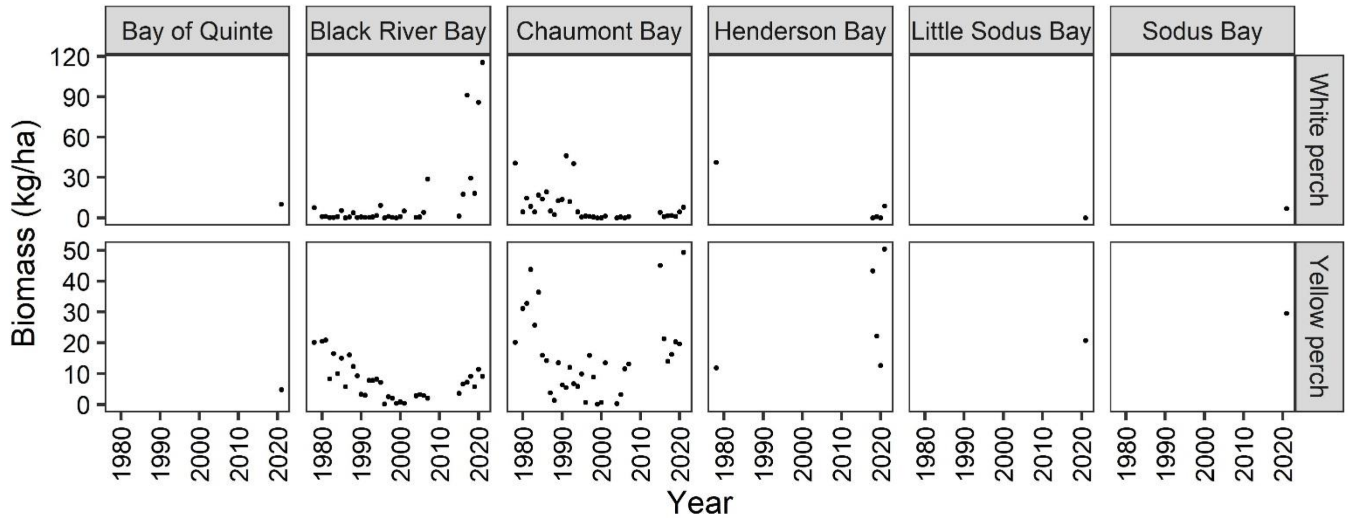

Figure 7. Mean biomass density (kg/ha) of yellow perch and white perch from trawl tows in embayments during the yellow perch survey 1978–2007 (O'Gorman and Burnett 2001), and during the benthic preyfish survey 2015–2021. Note that trawl sites in Chaumont, Black River, and Henderson Bays were added to the benthic preyfish survey beginning in 2015, and Bay of Quinte, Sodus, and Little Sodus Bays were added in 2021.