Bottom trawl assessment of benthic preyfish community in Lake Ontario

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Abstract

Since 1978, the Lake Ontario benthic preyfish 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 drastically increased the survey's spatial coverage. In 2020, the collaborative benthic preyfish survey completed 82 bottom trawl tows across main lake and embayments at depths from 6-226 m. Compared to previous years, the survey was largely confined to ports east of Rochester on the U.S. side, and east of Wesleyville on the Canadian side due to COVID-19 travel constraints. In total, the survey sampled 109,315 fish from 32 species in 2020. Round goby was the most numerically abundant species comprising 59% of total catch, followed by alewife (27%), and deepwater sculpin (7%). Despite being a common species represented in historical catches, slimy sculpin comprised only 0.05% of the total catch, with only 53 fish sampled in 2020. Annual biomass indices were among the lowest reported for slimy sculpin across the entire time series, whereas deepwater sculpin biomass remained high but showed a decrease from values observed in 2019. Deepwater sculpin condition in 2020 was lower than in 2019 but similar to values observed in 2017-2018. Community diversity remained high relative to historically lower values when round goby and deepwater sculpin were not captured in trawl catches. Round goby biomass in 2020 was the highest on the time series, highlighting the need to resume lake-wide sampling in 2021 to further understand how regional vs lake-wide sampling affects benthic preyfish population estimates.

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 continually measured Lake Ontario preyfish community status and trends since 1978 to provide information for decision making relative to those objectives.

Historically during the 1970-1980s, the benthic preyfish community was primarily composed of slimy sculpin, with lesser amounts of trout-perch, johnny darter, and spottail shiner, in terms of biomass. Recent bottom trawl surveys have documented a decline in slimy sculpin abundance, while at the same time shown increases in non-native round goby biomass beginning in 2005, and resurgence in native deepwater sculpin, considered to have been extirpated (Weidel et al. 2019). These large changes in the composition of the benthic preyfish community illustrate the importance of monitoring populations and improving survey design to provide the best information possible to understand and track population changes through time. Moreover, Lake Ontario preyfish surveys have routinely sampled the same lake areas across different seasons from April to October and 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, a native coregonine species that inhabits deep, offshore habitats was last caught by trawl surveys in 1983, indicating this species was also likely extirpated from the lake (Owens et al., 2003). Since 2012, bloater have been reintroduced through stocking and bottom trawl recaptures allow for tracking progress of the restoration program. 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. 2020).

Additionally, using similar gear types and trawling at similar times of year to other surveys conducted throughout the Great Lakes allow managers to interpret Lake Ontario preyfish dynamics at a basin-wide scale.

As was the case for all Great Lakes fisheries management and research agencies, the impacts of the COVID-19 pandemic on the U.S. Geological Survey (USGS) Great Lakes Science Center's deepwater science work were significant. The most severe impacts were related to deepwater science cruises scheduled in the spring/early summer, and those requiring extended overnight stays on vessels. In addition, USGS vessels could not get clearance to cross into Canadian waters as a result of the pandemic, reducing the scope of data normally collected by cruises that were able to get underway. Because of these limitations, reporting for 2020 deepwater science surveys will be limited in scope, and in some cases, limited in the ability to make meaningful comparisons to data from previous years. All USGS personnel involved in deepwater science cruises are looking forward to the return of a more normal sampling schedule in 2021, pandemic conditions permitting.

This report describes the status of Lake Ontario benthic preyfish community with emphasis on information addressing the bi-national (Ontario Ministry of Natural Resources and Forestry [OMNRF], and New York State Department of Environmental Conservation [NYSDEC]) Lake Ontario Committee's FCOs (Stewart et al., 2017). This research is also guided by USGS Ecosystems Mission Area science strategy that seeks to understand how ecosystems function and provide services, what drives ecosystems, and to develop science and tools that inform decision making related to ecosystem management, conservation and restoration (Williams et al., 2013).

Methods

From 1978-2011, 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; Figure 1). 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 (2.1m x 1m). The survey typically occurs during October but also includes sampling from September-November. Abundant dreissenid mussel catches 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 alternate trawls caught few demersal fishes and the alternative trawl doors influenced net morphometry (Weidel and Walsh, 2013). Since 2011, the survey has used the historical-standard Yankee trawl and doors but has reduced tow times to reduce mussel catches. Typical trawl tows in recent years have been 5 minutes depending on the amount of mussels. 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. At that time the NYSDEC and OMNRF research vessels joined the survey, which greatly expanded the spatial extent and diversity of habitats surveyed. Benthic preyfish time series are illustrated in this report from 1978 to present and no adjustments are available for data when the alternative trawls were used.

Trawl catches were sorted by species, counted, and weighed. Dreissenid mussels are 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 on 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 trawl effort, expressed as area swept, differed substantially from tow time based effort. Trawl results are expressed as biomass (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 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 for analysis 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 which only included U.S. waters. Annual area-weighted biomass indices expressed as kilograms per hectare were calculated for U.S waters (1978-2020), and lake-wide (2015-2020), using thirteen 20m strata (66ft) depth bins within the U.S. and Canadian areas of the lake (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).

Condition indices for deepwater sculpin are estimated using linear models that predict fish weight based on fish length (log scale), where the condition index value is the slope of the relationship in the benthic preyfish survey (fall) and the pelagic preyfish survey (spring) for reference. The pelagic preyfish survey (see Weidel et al. 2020 for details) was cancelled in 2020 due to logistical constraints with COVID but we included deepwater sculpin condition from previous years for reference. Benthic preyfish community diversity was quantified using the Shannon index based on trawl catch by weight (Shannon and Weaver, 1949) based on these primary benthic preyfish species: round goby, johnny darter, logperch, yellow perch, slimy sculpin, deepwater sculpin, spottail shiner, and trout-perch.

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 by the 1970s, was rare (Christie, 1973). Restoration in Lake Ontario began in 2012 by stocking bloater raised from eggs collected from Lake Michigan

(Connerton, 2018). Catches have been sporadically low since restoration stocking began but are reasonable based on our power to detect species at low abundance (Weidel et al., 2020). In 2020, no bloater were captured during the benthic preyfish survey. A manuscript is currently in preparation describing results from the Lake Ontario bloater restoration program and will be submitted to a scientific journal during the second quarter of 2021.

Slimy Sculpin – Slimy sculpin abundance indices in 2020 were among the lowest observed for the entire time series (Figure 2). 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 2019).

Deepwater Sculpin – Deepwater sculpin were the third most abundant preyfish in trawl catches during the benthic preyfish survey in 2020 (Table 2). Deepwater sculpin biomass has generally increased since 2010 (Weidel et al. 2017). In 2020, values were slightly lower than 2019 for both the US and whole lake biomass indices suggesting the population may be stabilizing however it is too early to draw a conclusion and the limited spatial coverage of the survey in 2020 may provide a biased estimate of the true abundance. Deepwater sculpin condition, as measured by the slope of the length weight relationship, decreased in 2020 relative to 2019, and was similar to low values observed in 2017 and 2018 from the fall time series (Figure 3).

Round Goby – Round goby biomass in 2020 was the highest on record for both the U.S. biomass index and the whole lake indices over the entire time series (Figure 2). Round goby was also the most abundant fish in trawl catches during the benthic preyfish survey in 2020 (Table 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; Walsh et al., 2007). Round goby are typically concentrated at shallower depths during the survey, and compared to previous years of the survey, there were relatively high catches in some eastern sites (Figure 4). We note that sampling during 2020 was restricted mainly to the eastern half of the lake, which, in light of these results, and known issues of variability with round goby density estimates, highlights the need to resume lake-wide sampling in 2021 to further understand how regional vs lake-wide sampling affects benthic preyfish population estimates.

Preyfish diversity – Lake Ontario FCOs seek to increase preyfish diversity (Stewart et al., 2017). Based on bottom trawl catches during the benthic preyfish survey, diversity of the primary benthic preyfish species in Lake Ontario is relatively high compared to historically lower values (Figure 5). Despite slimy sculpin declines, demersal preyfish community diversity has generally increased during the most recent decade. In the 1970s – 1990s, catches were dominated by slimy sculpin in the main lake, and deepwater sculpin were uncommon, which helps explain lower diversity values. More recently, deepwater sculpin and round goby comprise similar proportions of the trawl catch, increasing diversity relative to when only slimy sculpin dominated the catches.

Embayment Catches – Trawl catches at embayment sites sampled in 2020 (Chaumont Bay, Black River Bay, Henderson Bay) continue 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).

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Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health and Ontario's Great Lakes Strategy. NYSDEC funding was from the Federal Aid in Sport Fish Restoration Program. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government. The data associated with this report have not received final approval by the U.S. Geological Survey (USGS) and are currently under review. The Great Lakes Science Center is committed to complying with the Office of Management and Budget data release requirements and providing the public with high quality scientific data. We plan to release all USGS research vessel data collected between 1958 and 2020 and make those publicly available. Please direct questions to our Information Technology Specialist, Scott Nelson, at snelson@usgs.gov. All USGS sampling and handling of fish during research are carried out in accordance with guidelines for the care and use of fishes by the American Fisheries Society (http://fisheries.org/docs/wp/Guidelines-for-Use-of-Fishes.pdf).

Literature Cited

Christie, W.J., 1973. A review of the changes in the fish species composition of Lake Ontario (Technical Report No. 23). Great Lakes Fishery Commission, Ann Arbor, MI. Christie, W.J., 1973. A review of the changes in the fish species composition of Lake Ontario (Technical Report No. 23). Great Lakes Fishery Commission, Ann Arbor, MI.

Cochrane, W.G., 1977. Sampling Techniques, 3rd ed. Wiley, New York, NY.

Connerton, M.J., 2018. New York Lake Ontario and Upper St. Lawrence River Stocking Program 2017, in: NYSDEC (Ed.), NYSDEC 2017 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee. Albany, NY, pp. 1.1-1.14.

Ives, J.T., McMeans, B.C., McCann, K.S., Fisk, A.T., Johnson, T.B., Bunnell, D.B., Frank, K.T., Muir, A.M., 2019. Food-web structure and ecosystem function in the Laurentian Great Lakes—Toward a conceptual model. Freshwater Biology 64, 1-23.

Owens, R.W., Dittman, D.E., 2003. Shifts in the Diets of Slimy Sculpin (Cottus cognatus) and Lake Whitefish (Coregonus clupeaformis) in Lake Ontario Following the Collapse of the Burrowing Amphipod Diporeia. Aquat. Ecosyst. Health Manag. 6, 311–323. https://doi.org/10.1080/14634980301487

Pennuto, C.M., Mehler, K., Weidel, B., Lantry, B.F., Bruestle, E., 2021. Dynamics of the seasonal migration of Round Goby (Neogobius melanostomus, Pallas 1814) and implications for the Lake Ontario food web. Ecology of Freshwater Fish.

Ray, W.J., Corkum, L.D., 2001. Habitat and site affinity of the round goby. J. Gt. Lakes Res. 27, 329–334.

Shannon, C.E., Weaver, W., 1949. The mathematical theory of communication. The University of Illinois Press, Urbana, IL.

Stewart, T.J., Todd, A., Lapan, S., 2017. Fish community objectives for Lake Ontario (Great Lakes Fisheries Commission Special Publication). Ann Arbor, MI.

Volkel, S.L., 2019. Evaluation of changes in sculpin populations in the Great Lakes associated with shifts in benthic species composition. Michigan State University. Fisheries and Wildlife. MS Thesis.

Weidel, B.C., O'Malley, B.P., Connerton, M.J., Holden, J.P., Osborne, C.A. 2020. Bottom trawl assessment of Lake Ontario preyfishes, 2019 in: NYSDEC 2019 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee. Albany, NY, p. section 12.

Weidel, B.C., Connerton, M.J., Holden, J.P., 2018. Bottom trawl assessment of Lake Ontario preyfishes, in: NYSDEC (Ed.), NYSDEC 2017 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee. Albany, NY, pp. 12.1-12.18.

Weidel, B.C., Connerton, M.J., Walsh, M.G., Holden, J.P., Holeck, K.T., Lantry, B.F., 2019. Lake Ontario Deepwater Sculpin recovery: an unexpected outcome of ecosystem change, in: Krueger, C.C., Taylor, W., Youn, S.-J. (Eds.), Catastrophe to Recovery: Stories of Fishery Management Success. American Fisheries Society, Bethesda Maryland.

Weidel, B.C., Walsh, M.G., 2013. Estimating the area-swept by the 11.8 m Yankee bottom trawl in Lake Ontario, in: NYSDEC (Ed.), NYSDEC 2012 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes

Fishery Commission's Lake Ontario Committee. Albany, NY, pp. 12.25-12.32.

Weidel, B.C., Walsh, M.G., Connerton, M.J., Lantry, B.F., Lantry, J.R., Holden, J.P., Yuille, M.J., Hoyle, J.A., 2017. Deepwater sculpin status and recovery in Lake Ontario. J. Gt. Lakes Res. https://doi.org/10.1016/j.jglr.2016.12.011

Williams, B., Wingard, L., Brewer, G., Cloern, J., Gelfenbaum, G., Jacobson, R., Kershner, J., McGuire, A., Nichols, J., Shapiro, C., van Riper III, C., White, R., 2013. U.S. Geological Survey Ecosystems Science Strategy—Advancing Discovery and Application through Collaboration.

Table 1. Proportion of Lake Ontario surface area by 20m depth strata that falls 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 total fish caught in fall 2020 benthic preyfish survey and the mean number caught in recent survey years (2015-2019) for context. Dreissenid mussel catch (**Dreissena*** ***spp.) is represented by weight in kilograms. Values include all Lake Ontario sampling sites including Canadian waters.***

Common name	N in 2020	Avg. N (2015-2019)
Round goby	63976	33755
Alewife	29200	23190
Deepwater sculpin	7405	9177.4
Rainbow smelt	3479	3266.8
White perch	2122	923.6
Yellow perch	1178	2022
Gizzard shad	771	227.8
Trout-perch	498	1201
Spottail shiner	236	350
Brown bullhead	189	106.2
Pumpkinseed	59	58.8
Slimy sculpin	53	850.6
White sucker	48	96.2
Darters	24	16
Emerald shiner	21	62.4
Freshwater drum	10	41.8
Carp	9	7.6
Lake trout	6	60.8
Logperch	5	8
Unidentified shiner	4	0
Cisco (lake herring)	3	0.4
American brook lamprey	3	0
Sea lamprey	2	0.6
Lake sturgeon	2	0.4
Lake whitefish	2	4.4
Walleye	2	5.2
Channel catfish	2	0.8
Quillback	2	0.8
Black crappie	2	0
Smallmouth bass	1	0.8
Rockbass	1	1
American eel	0	0.2
Threespine stickleback	0	219
White bass	0	13.4
Round whitefish	0	0.4
Chinook salmon	0	0.4
Brown trout	0	1.2
Mottled sculpin	0	0.4
Northern pike	0	0.4
Brook stickleback	0	2.4
Bluntnose minnow	0	5.6
Largemouth bass	0	2.6
Bloater	0	0.4
Dreissenid mussel (weight in kg)	2041	3978

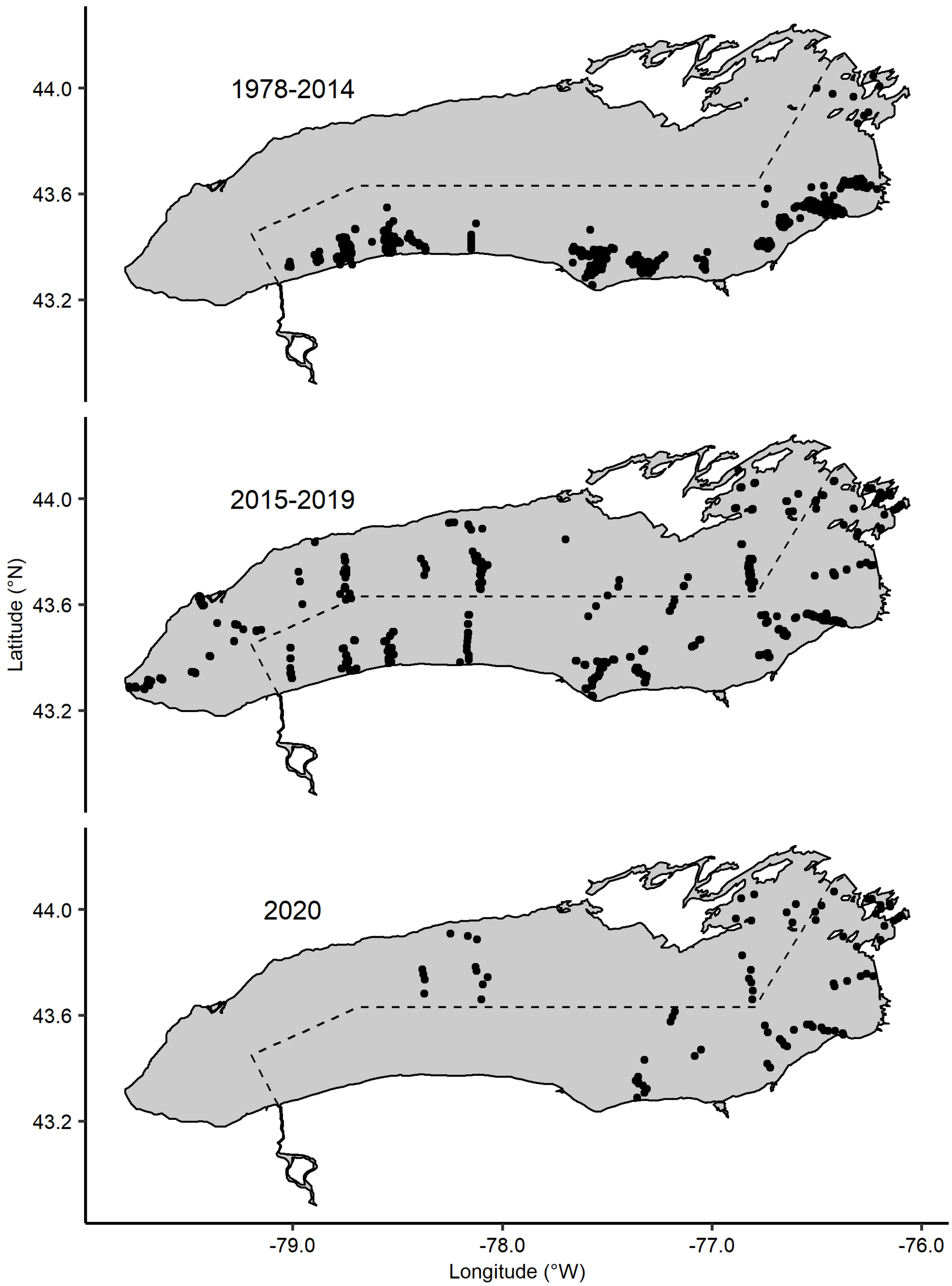

Figure 1. Lake Ontario bottom trawl sites sampled during the benthic preyfish survey since its beginning by time-period (top: 1978-2014; middle: 2015-2019; bottom: 2020). Since 1978 the survey has sampled sites along the U.S shore, and starting in 2015, the survey has expanded lake-wide to include Canadian sites and deeper offshore U.S. sites. The recent 2020 survey continued to sample in U.S. and Canadian waters but was constrained to mostly eastern sites compared to 2015-2019. In 2020, 82 bottom trawls tows were collectively sampled by the USGS, OMNRF, and NYSDEC during the benthic preyfish survey September 28- October 22, 2020. Dashed line represents the U.S.-Canada international boundary.

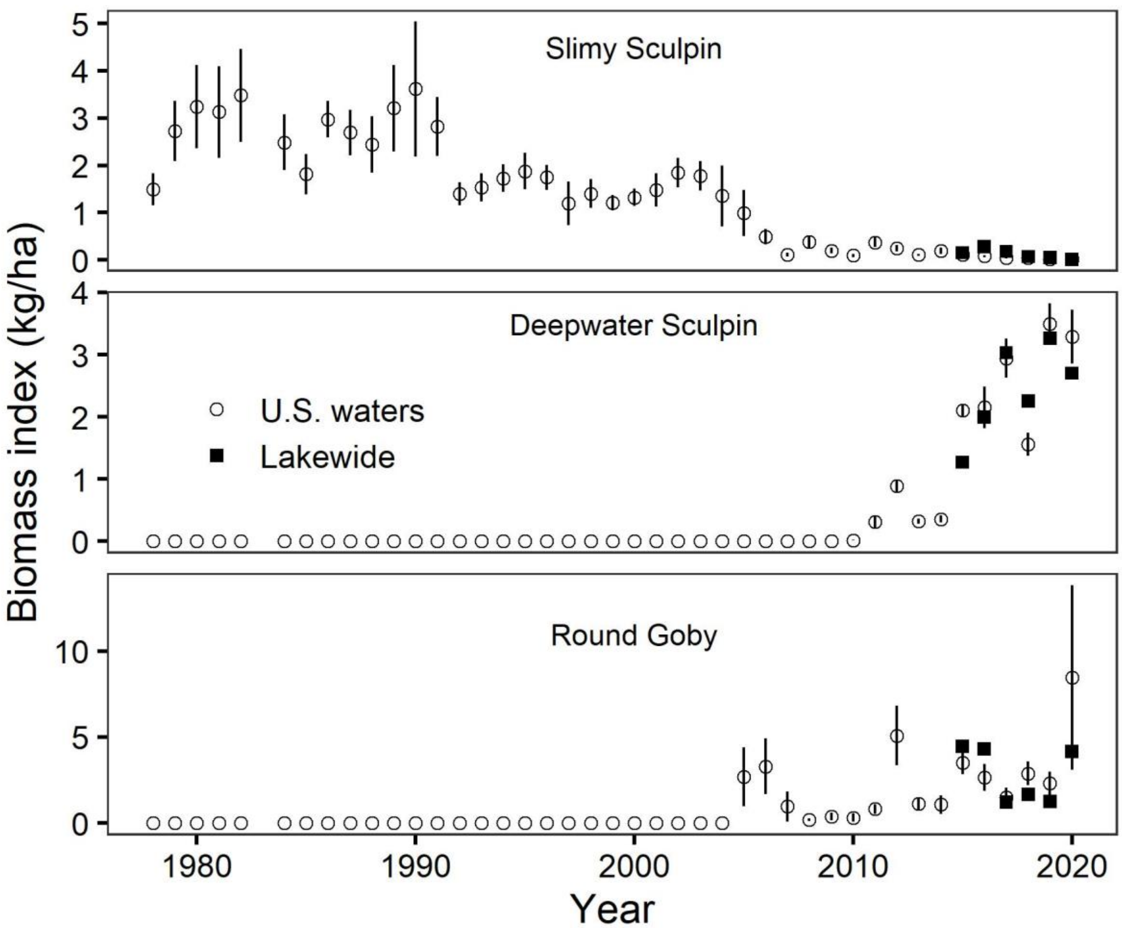

Figure 2. Area-stratified biomass density (kilograms per hectare) for slimy sculpin, deepwater sculpin, and round goby in the benthic preyfish survey 1978-2020. Open symbols represent the index for U.S. waters only, and closed squares represent lake-wide values that include trawls from both U.S. and Canadian waters.

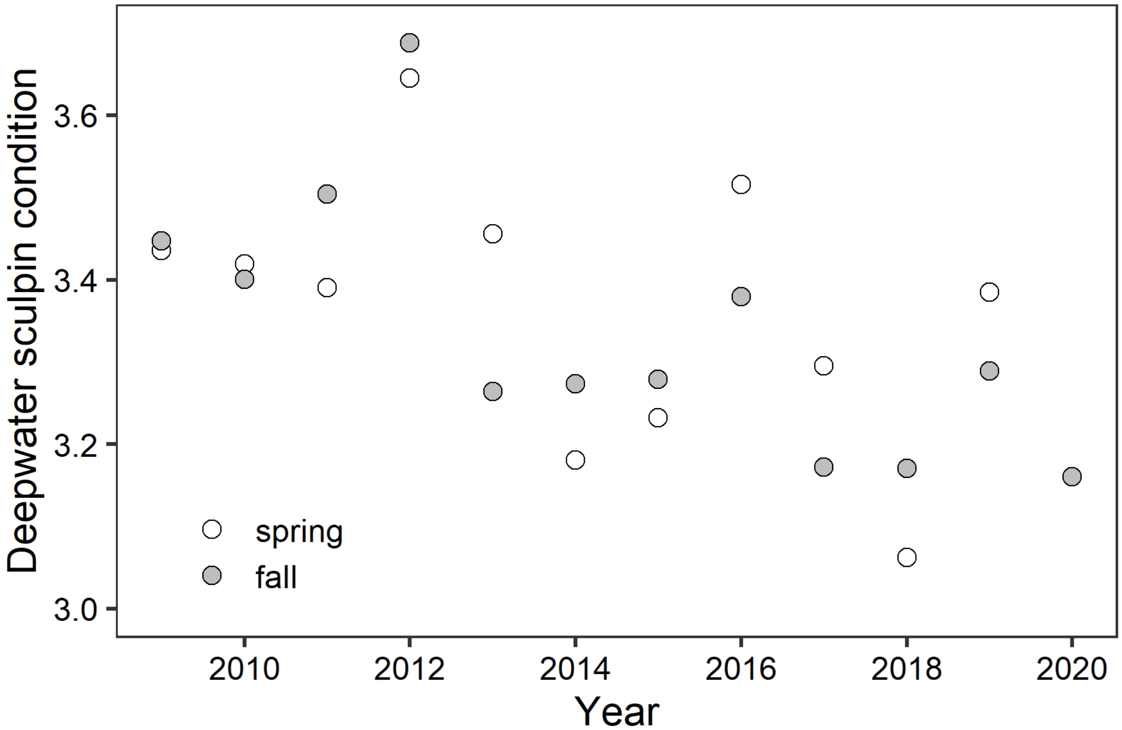

Figure 3. Condition indices for deepwater sculpin > 75 mm (total length) based on the benthic preyfish (fall) and spring survey. The spring survey was cancelled in 2020.

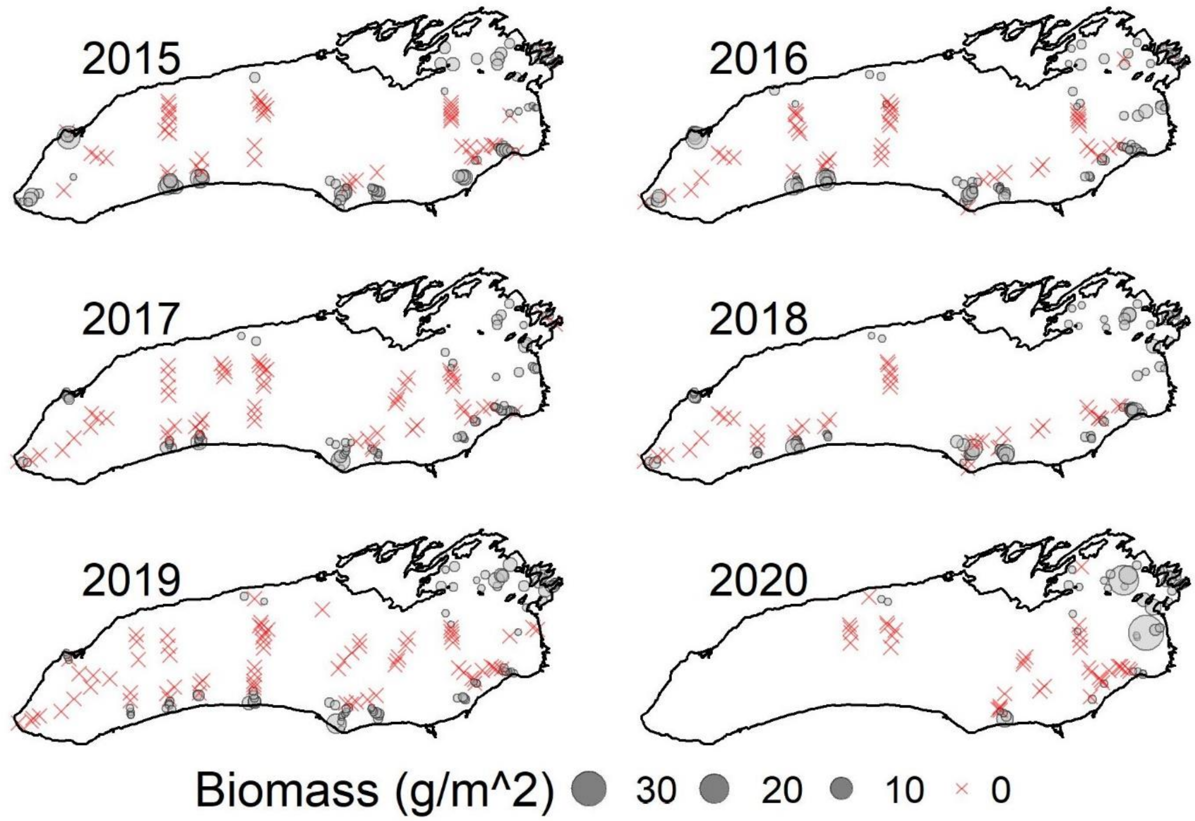

Figure 4. Spatial distribution of round goby biomass estimates (g/m^2) in Lake Ontario from individual trawl tows during the benthic preyfish survey 2015-2020.

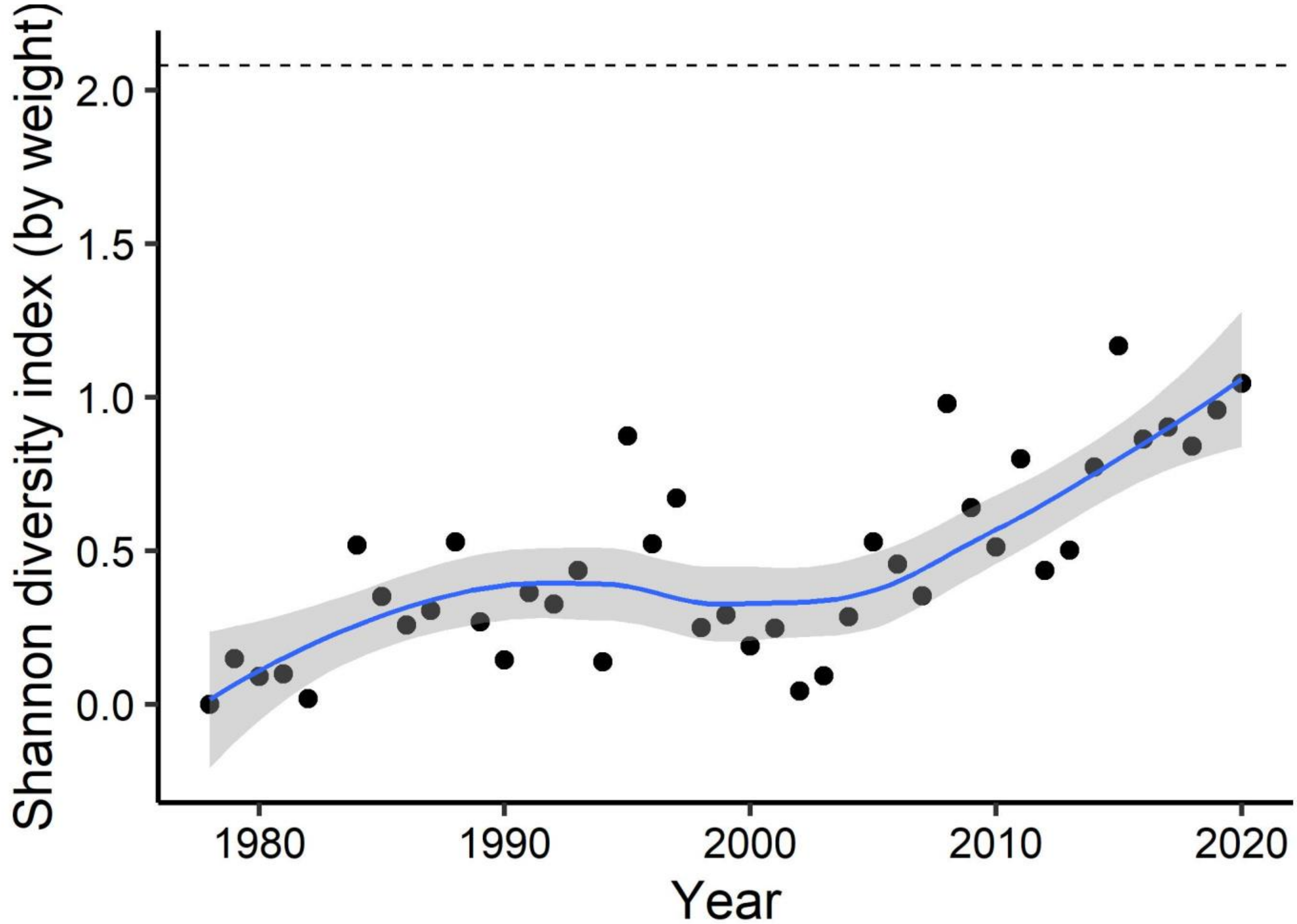

Figure 5. Shannon diversity index of benthic preyfish community through time based on trawl catch weight. Solid line represents the LOESS trend and grey ribbon is the 95% confidence interval.

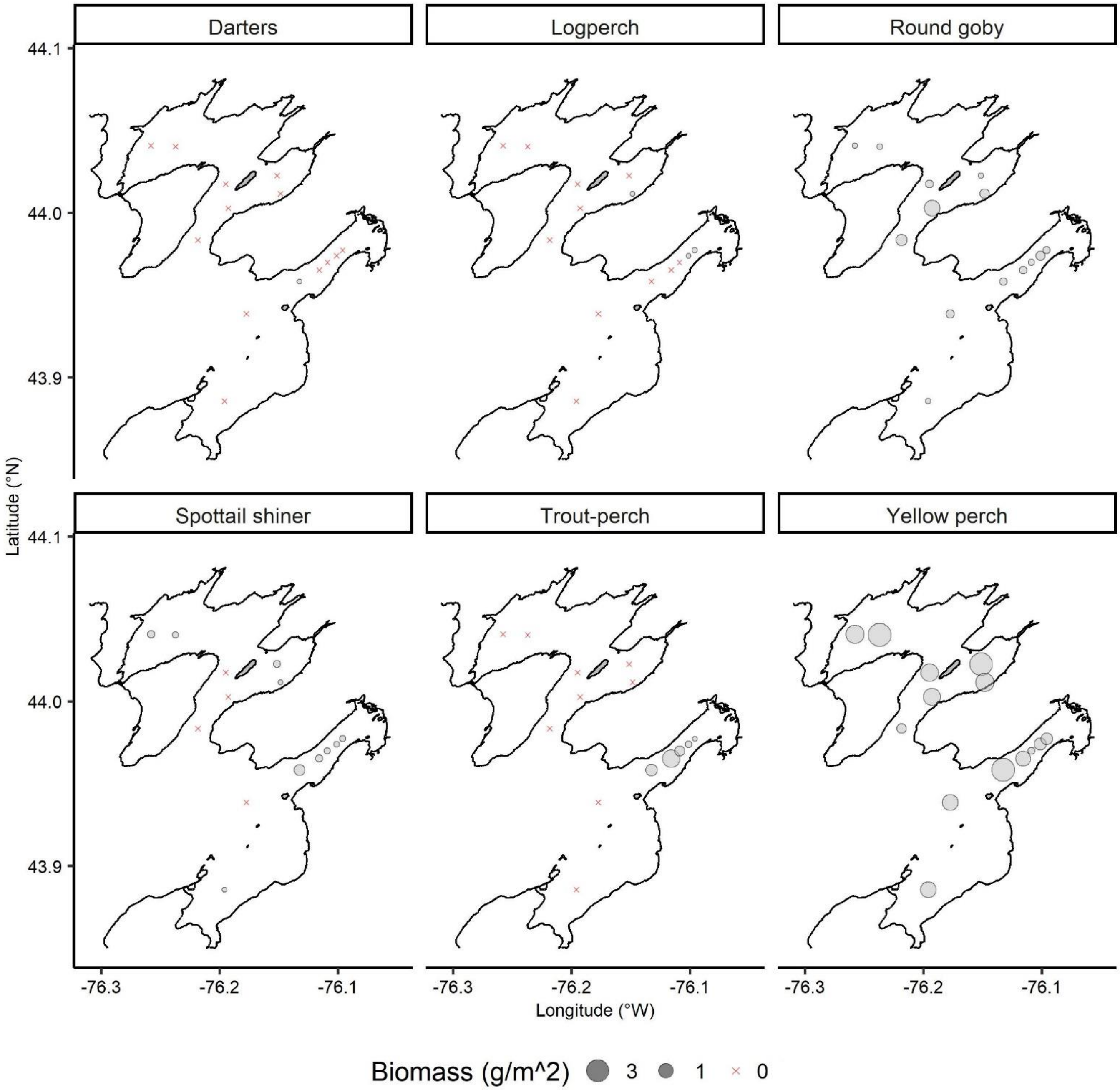

Figure 6. Spatial distribution of biomass estimates (g/m^2) from individual trawl tows of various preyfish species in Chaumont, Black River, and Henderson Bays in eastern Lake Ontario from the 2020 benthic preyfish survey.