Fisheries Research and Monitoring Activities of the Lake Erie Biological Station, 2019[1]

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Scientific Names

The following scientific names correspond to the common names of fishes captured during surveys described in this report:

Scientific name	Common name	Scientific name	Common name
Acipenser fulvescens	Lake Sturgeon	*Micropterus dolomieu*	Smallmouth Bass
Alosa pseudoharengus	Alewife	*Micropterus salmoides*	Largemouth Bass
Ambloplites rupestris	Rock Bass	*Morone americana*	White Perch
Ameiurus nebulosus	Brown Bullhead	*Morone chrysops*	White Bass
Aplodinotus grunniens	Freshwater Drum	*Moxostoma anisurum*	Silver Redhorse
Carassius auratus	Goldfish	*Moxostoma erythrurum*	Golden Redhorse
Carpiodes cyprinus	Quillback	*Moxostoma macrolepidotum*	Shorthead Redhorse
Catostomus commersonii	White Sucker	*Neogobius melanostomus*	Round Goby
Coregonus clupeaformis	Lake Whitefish	*Notropis atherinoides*	Emerald Shiner
Cyprinus carpio	Common Carp	*Notropis hudsonius*	Spottail Shiner
Dorosoma cepedianum	Gizzard Shad	*Notropis volucellus*	Mimic Shiner
Esox masquinongy	Muskellunge	*Osmerus mordax*	Rainbow Smelt
Ichthyomyzon unicuspis	Silver Lamprey	*Perca flavescens*	Yellow Perch
Ictalurus punctatus	Channel Catfish	*Petromyzon marinus*	Sea Lamprey
Labidesthes sicculus	Brook Silverside	*Percina caprodes*	Logperch
Lepomis macrochirus	Bluegill	*Percopsis omiscomaycus*	Trout-perch
Lota	Burbot	*Salvelinus namaycush*	Lake Trout
Macrhybopsis storeriana	Silver Chub	*Sander vitreus*	Walleye

Executive Summary

A comprehensive understanding of fish populations and their interactions is the cornerstone of modern fishery management and the basis for Fish Community Goals and Objectives for Lake Erie (Ryan et al. 2003). This report is responsive to U.S. Geological Survey (USGS) obligations via Memorandum of Understanding (MOU) with the Great Lakes Council of Lake Committees (CLC) to provide scientific information in support of fishery management. Goals for the USGS Great Lakes Deepwater Fish Assessment and Ecological Studies in 2019 were to monitor long-term changes in the fish community and population dynamics of key fishes of interest to management agencies. Specific to Lake Erie, expectations of this agreement were sustained investigations of native percids, forage (prey) fish populations, and Lake Trout.

Our 2019 deepwater program operations began in April and concluded in December, and utilized trawl, gillnet, hydroacoustic, lower trophic sampling, and telemetry methods. This work resulted in 88 bottom trawls covering 65 ha of lake-bottom and catching 24,140 fish totaling 3,622 kg during three separate trawl surveys in the West and Central basins of Lake Erie. Overnight gillnet sets (n=44) for cold water species were performed at 42 unique locations in the West and East basins of Lake Erie. A total of 8.0 km of gillnet was deployed during these surveys, which caught 286 fish, 114 of which were native coldwater species: Lake Trout, Burbot, and Lake Whitefish. USGS hydroacoustic surveys in 2019 produced 240 km of transects, and lower trophic sampling provided data from zooplankton samples (n=21) and water quality profiles (n=21) to populate a database maintained by the Ontario Ministry of Natural Resources and Forestry (OMNRF), Ohio Division of Natural Resources (ODNR), Michigan Division of Natural Resources (MDNR), Pennsylvania Fish and Boat Commission (PFBC), and New York State Department of Environmental Conservation (NYSDEC). USGS also assisted CLC member agencies with deployment and maintenance of the Great Lakes Acoustic Telemetry Observation System (GLATOS) throughout all three Lake Erie sub-basins, supporting multiple coordinated telemetry investigations.

In 2019, Lake Trout investigations included annual gill net surveys and acoustic telemetry of spawning migration and habitat use in coordination with OMNRF, NYSDEC, and PFBC. Results from Lake Trout investigations were reported in the Coldwater Task Group annual report to the Great Lakes Fishery Commission (GLFC) and the CLC (Coldwater Task Group 2020). Likewise, interagency forage fish assessments conducted with hydroacoustics were summarized and reported in the Forage Task Group annual report (Forage Task Group 2020).

This report presents biomass-based summaries of fish communities in western Lake Erie derived from USGS bottom trawl surveys conducted from 2013 to 2019 during June and September. The survey design provided temporal and spatial coverage that did not exist in the historic interagency trawl database, and thus complemented the August ODNR-OMNRF effort to reinforce stock assessments with more robust data. Analyses herein evaluated trends in: total biomass, abundance of dominant predator and forage species, non-native species composition, biodiversity and community structure. Data from this effort can be explored interactively online (https://lebs.shinyapps.io/western-basin/), and are

accessible for download (https://doi.org/10.5066/P9LL6YOR, Keretz et al. 2020). Annual survey data are added to these sources as the data become available.

Introduction

Lake Erie has the highest human population of any of the Great Lakes' watersheds, and as such has undergone dramatic anthropogenic changes. Since the 1800s, stressors such as overexploitation, habitat destruction, exotic species introduction, industrial contamination, and changes in nutrient loading have resulted in substantial changes affecting the fish community. The most notable changes have been declines in or extirpation of many native species (Hartman 1973; Leach & Nepszy 1976; Ludsin et al. 2001). Since the implementation of the Clean Water Act and Great Lakes Water Quality Agreement in the 1970s, habitat conditions for fish have improved, which in part has resulted in several strong percid year-classes (e.g. Walleye Task Group 2020). These strong year-classes benefited from more restrictive management that ultimately rehabilitated Lake Erie percid stocks.

Today, the primary goal of fishery resource managers in Lake Erie is "To secure a balanced, predominantly cool-water fish community characterized by self-sustaining indigenous and naturalized species that occupy diverse habitats, provide valuable fisheries, and reflect a healthy ecosystem (Ryan et al. 2003)," yet there is little guidance on what fish community characteristics indicate a balanced and healthy Lake Erie ecosystem. Historically, Lake Erie's mesotrophic cool water habitats supported harmonic percid and salmonid fish communities, and it is the aim of management to re-establish these communities.

Although Lake Erie management agencies have traditionally focused on numerical indices of a few economically important species (primarily Walleye, Yellow Perch, Lake Trout, and Smallmouth Bass), aquatic ecosystem models are typically evaluated in terms of biomass. Most time series of fish community data from Lake Erie do not contain measurements of biomass. Therefore, our understanding of fish community structure and ecosystem dynamics from mass-balance models has been limited to short-term investigations and proxy measurements (e.g., length-weight conversion).

In response to this need, USGS revised the Lake Erie trawl program to provide biomass-based measurements of fish population dynamics and ecosystem condition for Lake Erie. This change occurred in 2012, coincident with the switch to a new research vessel. Because the previously used trawl gear would not fish properly from the new vessel, we changed to a different bottom trawl. As this situation marked the beginning of a new time series of data, the sampling design was expanded to include greater spatial coverage and increased sample size. Note that traditional numerically-based catch data (e.g., number per hectare) for individual species can be explored and downloaded online (from 2013 to present - https://lebs.shinyapps.io/western-basin/, https://doi.org/10.5066/P9LL6YOR) or obtained for earlier years (https://doi.org/10.5066/F75M63X0). The purpose of this report was to develop a comprehensive understanding of the long-term changes and population dynamics of key fishes of interest to management agencies, including native percids and their forage. Here, we summarized survey results for the most recent series of western basin trawl data from 2013 through 2019.

Methods

Survey Area and Sampling Design

During 2013-2019, we conducted a grid-based sampling design in both June and September, referred to here as spring and autumn, respectively (Figure 1). This sampling design complemented the time series of combined trawling efforts between ODNR and OMNRF in August, and together these surveys provide a foundation for addressing ongoing and emerging issues defined by Lake Erie task groups. The sampling domain was west of the Lorain ridge, which acts as a natural boundary between the relatively shallow West basin and deeper Central basin (Figure 1).

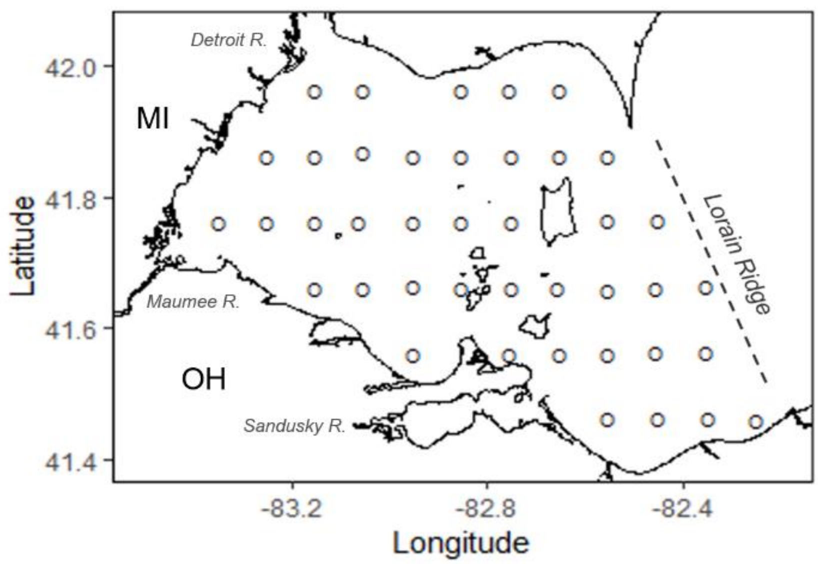

Figure 1. Target bottom trawl locations (n=41) west of the Lorain ridge (dotted line) sampled by U.S. Geological Survey Lake Erie Biological Station between 2013 and 2019.

Sampling locations were selected both to accommodate the trawling net used on the R/V Muskie (no shallower than head-rope height ~3 m), and to effectively evaluate fish populations at all deep-water habitats in western Lake Erie, which included areas of the main basin, Lake Erie Islands and major river mouths (Detroit, Sandusky, and Maumee rivers). The spacing of the grid was six minutes of longitude (E-W) and latitude (N-S), and sampling took place at the origin. This spacing was chosen to maximize our spatiotemporal coverage and provide the maximum number of locations that could be sampled within a week (n=41). Due to navigation concerns, the entire grid was shifted south by 1.85 km after the spring sampling trip in 2013 to avoid conflict with large boats using the shipping lanes. In spring of 2017, only 36 sites were sampled due to a structural failure of the trawl gallows when the net became snagged on the lake bottom. In spring of 2018, no trawling was conducted due to maintenance and repair of the research vessel while in dry-dock.

Results and Discussion

The 2019 spring and autumn surveys took place during the weeks of June 16 and September 15, respectively. We sampled all 41 sites in both surveys, trawling a total area of 61 hectares (32 ha spring, and 29 ha autumn). Variability in area swept between seasons was due to snags and/or barge traffic described in Keretz et al. (2020). Surveys caught a total fish biomass of 3,510 kg (21,848 fish). Catches were largest in the spring, totaling 2,148 kg (5,395 fish from 22 species). Autumn catches totaled 1,362 kg (16,453 fish from 21 species).

Trends in Biomass and Community Composition

Total biomass in trawl catches declined by approximately 70% from 310 kg/ha in spring of 2013 to 96 kg/ha in autumn of 2019 (Table 1). This decline was not attributed to any single taxon, but was observed across the assemblage and functional groups, including predators (percids and moronids), forage fishes (Emerald Shiners, Gizzard Shad, and Rainbow Smelt), and large benthic species (Freshwater Drum, Quillback, Common Carp, and Channel Catfish).

Table 1: Survey summaries of catch (kg/ha) for total and forage species (± s.d.), biomass proportion of non-native species, and Shannon Diversity index (Morris et al. 2014) values.

Year	Season	n	Total	Forage	Non-Native Proportion	Shannon Diversity
2013	Spring	41	310 ± 249	52.2 ± 111.4	0.12	0.22
2013	Autumn	41	235 ± 154	4.9 ± 8.98	0.24	1.81
2014	Spring	41	194 ± 173	11.8 ± 25.75	0.13	0.74
2014	Autumn	41	178 ± 113	12.2 ± 21.04	0.25	1.60
2015	Spring	41	122 ± 100	5.4 ± 19.22	0.10	1.02
2015	Autumn	41	86 ± 66	4.9 ± 5.79	0.15	1.58
2016	Spring	41	101 ± 75	0.1 ± 0.12	0.09	1.24
2016	Autumn	41	74 ± 57	3.5 ± 6.35	0.22	1.98
2017	Spring	36	96 ± 69	0.4 ± 1.08	0.17	1.68
2017	Autumn	41	46 ± 43	2.6 ± 4.73	0.19	0.80
2018	Spring	0	–	–	–	–
2018	Autumn	41	88 ± 52	4.8 ± 9.42	0.11	1.86
2019	Spring	41	136 ± 108	0.1 ± 0.20	0.05	1.49
2019	Autumn	41	96 ± 102	2.6 ± 3.70	0.15	1.84

Forage biomass averaged 2.6 kg/ha in 2019 during autumn sampling (Table 1). Catches of Emerald Shiner peaked at 51.5 kg/ha in spring 2013 and were <0.1 kg/ha in autumn 2019 (Figure 2). During 2013-2019, Rainbow Smelt catches were low and varied from <0.01 kg/ha to 0.11 kg/ha (Figure 2). Similarly, Gizzard Shad were also low and variable, but typically higher in autumn than spring historically, reflecting the occurrence of young-of-year fish (Figure 2).

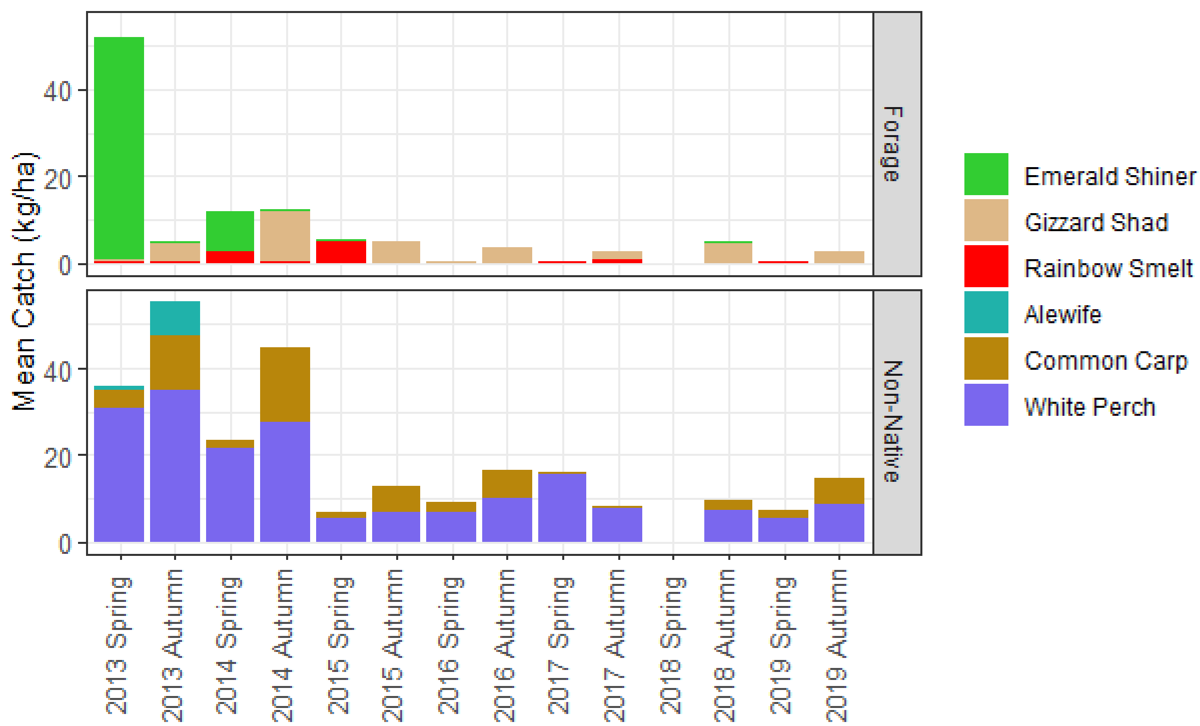

Figure 2. Stacked bar plots of catch of primary forage (upper panel) and non-native (lower panel) fishes from trawls in western Lake Erie. Rainbow Smelt belong to both categories but are only plotted in the upper panel to conform with Lake Erie task group conventions. Also, note that Round Goby, Sea Lamprey, and Goldfish are non-native species that were not plotted due to very low abundances in trawls.

The biomass proportion of non-native catch was less than 0.25 throughout the survey, averaging 0.15 (s.d.= 0.05) over the seven years (Table 1). The dominant non-native species either declined or showed little evidence of trends. White Perch averaged 14.51 kg/ha (s.d. = 10.22) across the series, with catch rates of 8.72 kg/ha in autumn of 2019 (Figure 2). Common Carp represented the second most abundant non-native species by biomass and varied from 0.38 to 17.02 kg/ha (mean = 4.77 kg/ha, s.d. = 4.78; Figure 2) during 2013-2019. After relatively large mean catches of Alewife in 2013 (0.69 kg/ha and 7.69 kg/ha in spring and autumn, respectively) very few (<0.01 kg/ha) to none were captured from 2014-2019 (Figure 2). Other non-native species (Round Goby, Goldfish, Sea Lamprey) were captured in low abundances (<0.1 kg/ha) during annual surveys.

Despite the decrease in total biomass, biodiversity of trawl catches was variable and ranged from 0.22 to 1.98 (Shannon Diversity index, Morris et al. 2014, Table 1). Diversity tended to be higher in autumn than spring, except in 2017 when the opposite pattern was due to the presence of one additional species (Lake Whitefish) in spring catches (Table 1).

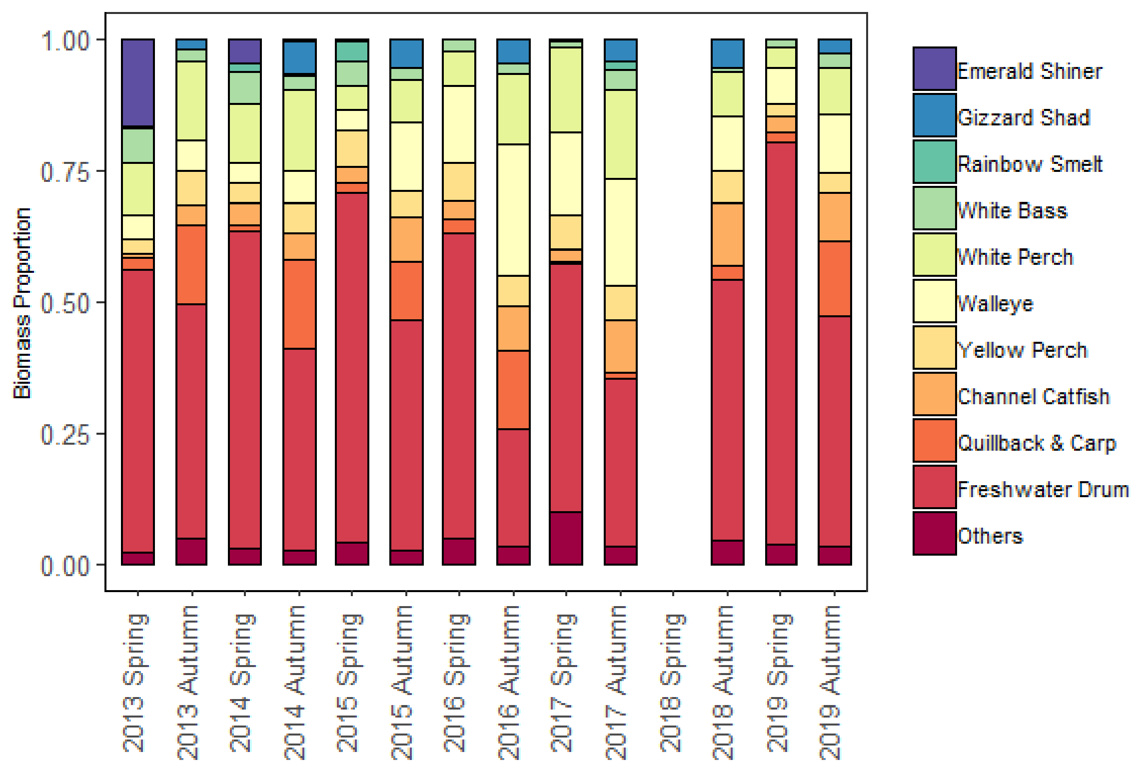

Figure 3. Biomass proportion of fish in bottom trawls in western Lake Erie.

Similar to the numerically-based Shannon Diversity estimates of fish community structure, species biomass composition varied little across the series. While large benthic species (Freshwater Drum, Common Carp, Quillback, and Channel Catfish) were not numerically dominant, they accounted for 50% or more of the total catch biomass during nearly every sampling season (Figure 3; numerical versus biomass summaries can be explored here: https://lebs.shinyapps.io/western-basin/).

Freshwater Drum dominated the biomass proportion with percentages as high as ~80% in spring 2019 (Figure 3). Although it has remained the dominant single species by biomass (except in autumn 2016), Freshwater Drum biomass proportion fluctuated from 25% to 80% since autumn 2016 (Figure 3). By comparison, the proportions of other large benthic species, such as Channel Catfish, Common Carp and Quillback, have remained relatively constant across the series (Figure 3). Other non-forage species that dominated the biomass composition of the catch were percids (Walleye and Yellow Perch) and moronids (White

Perch and White Bass). Both moronid species and Yellow Perch biomass proportions were relatively constant across the series, but Walleye (adults and juveniles) increased from an average of 5.08% (s.d. = 1.16) prior to 2015 to 13.1% (s.d. = 6.06) of the catch biomass in recent years (Figure 3). The proportion of Gizzard Shad to the overall catch has remained stable over the 7-year survey (~5-10%), while contributions from other forage species (Emerald Shiner and Rainbow Smelt) declined across the series to below 5%.

Trends in Percids

Age-0 Yellow Perch density in 2019 decreased (26.57 fish/ha) after an increase in density in 2018 (Figure 4). A larger peak in fish density was observed for age-0 Yellow Perch in 2014 and 2018, and although we expected a corresponding peak in age-1 density one year later, the data did not exhibit such a pattern (Figure 4). By comparison for Walleye, a lagged year-class signal was evident in age-0 and age-1 density peaks corresponding to the 2015 year-class (age-0 = 69.67 fish/ha; Figure 4). Further an increase in Walleye age-0 density from 2018 was also reflected by an increase in age-1 density from 2019. The increased density of age-0 Walleye in 2019 may be a precursor to increased density of age-1 Walleye in 2020; however, cross-validations of Walleye year-class variability from this survey require additional years of data.

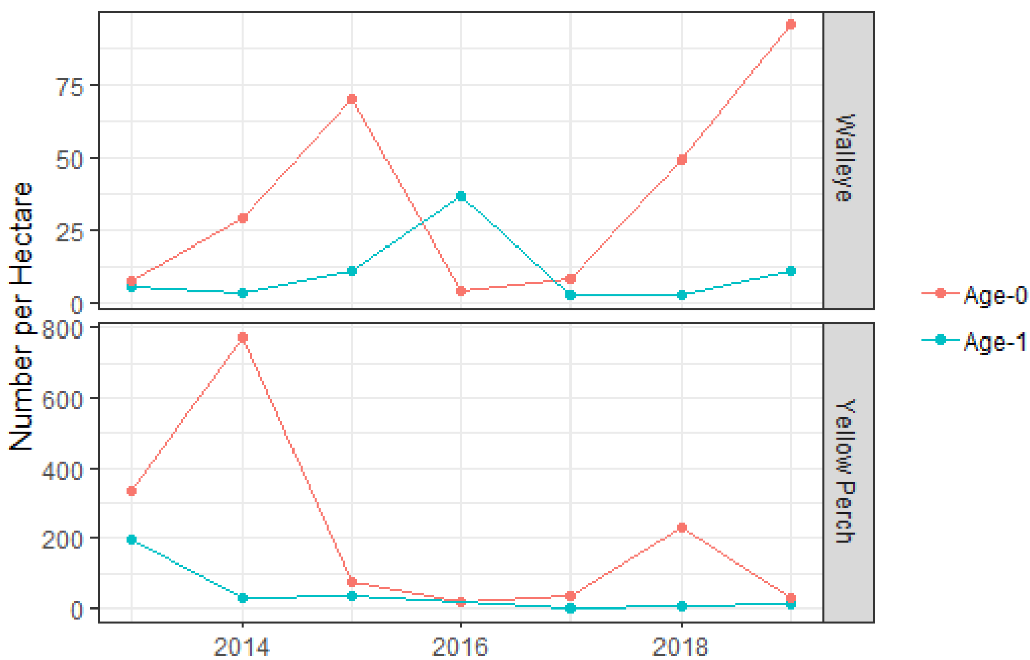

Figure 4. Mean number per hectare of age-0 and age-1 Walleye (upper panel) and Yellow Perch (lower panel) in bottom trawls from western Lake Erie during autumn.

Summary

While biomass of bottom trawl catches declined dramatically between 2013 and 2015, total biomass has stabilized at lower levels since 2016. Describing cycles of fish population abundance often require a long time series in the Laurentian Great Lakes (e.g. Vinson et al. 2014); therefore, trends from a seven-year data series should be interpreted cautiously. This survey provided new perspectives not immediately available from existing monitoring efforts to support goals of natural resource management efforts to establish a mesotrophic ecosystem with a harmonic cool-water species assemblage of forage fish and percids (Ryan et al. 2003). Notably, other Lake Erie surveys (e.g. Forage Task Group 2019) have underemphasized the importance of Freshwater Drum because they tend to report numerical instead of biomass-based measures of relative abundance. The potential for Freshwater Drum to impact invasive dreissenid mussels has only been evaluated superficially (French & Bur 1996), but due to its dominance in the fish community, this species has potential to contribute substantially to the remineralization of phosphorous in Lake Erie through the consumption of mussels (e.g., Johnson et al. 2005). Data presented herein, along with other surveys, highlight the need to better understand mechanisms driving forage fish abundance. Adult Walleye and Yellow Perch have historically relied on Gizzard Shad and Emerald Shiner as primary forage (Knight et al. 1984). Particularly for Walleye, which have experienced strong year-classes in 2015, 2018, and 2019, the low abundance of forage in western Lake Erie may result in reduced growth and early emigration (Madenjian et al. 1996; Wang et al. 2007). Diet investigations that incorporate ontogenetic changes in spatial distribution may be needed to better inform potential management actions that would ensure sustainable fisheries in Lake Erie. Such efforts will require surveys like the one presented in this report for obtaining samples but require further analysis of samples to quantify diet data.

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