# Fisheries Research and Monitoring Activities of the Lake Erie Biological Station, 2020[1]

Prepared by (in alphabetical order) Kevin R. Keretz, Patrick M. Kočovský, Richard T. Kraus, James J. Roberts, and Joseph D. Schmitt.

*Department of the Interior, U.S. Geological Survey*

*Great Lakes Science Center, Lake Erie Biological Station*

*6100 Columbus Avenue, Sandusky, Ohio 44870*

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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 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 Lake Erie's Fish Community Goals and Objectives (FCOs) developed in 2020 (Francis et al. 2020). The 2020 USGS Lake Erie Biological Station annual report is responsive to these FCOs and the U.S. Geological Survey (USGS) obligations via a Memorandum of Understanding (MOU) in 2004 with the GLFC 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 were to monitor long-term changes in the fish community and population dynamics of key fishes of interest to management agencies (MOU 2004). Specific to Lake Erie, expectations of the MOU were sustained investigations of native percids, forage (prey) fish populations, and Lake Trout. Additionally, this work was conducted under the authority of the Great Lakes Fishery Research Authorization Act of 2019.

The USGS 2020 deep water science fieldwork began in Lake Erie in March, 2020, and concluded in January, 2021, utilizing trawl, gillnet, hydroacoustic, lower trophic sampling, and telemetry methods. This work resulted in 26 bottom trawls covering 17 ha of lake-bottom and catching 10,551 fish totaling 777 kg in the West Basin of Lake Erie. Due to travel restrictions associated with the SARS-CoV-2 pandemic, annual gillnet assessments in the East and West Basins of Lake Erie for cold-water species did not take place; however, the R/V Muskie did deploy 1.5 km of gill nets to help Michigan Division of Natural Resources (MDNR) complete their Walleye assessment surveys. USGS hydroacoustic surveys produced 240 km of transects, and lower trophic sampling provided data from zooplankton samples (n=21) and water quality profiles (n=21) for a database maintained by the MDNR, Ontario Ministry of Natural Resources and Forestry (OMNRF), Ohio Department of Natural Resources (ODNR), Pennsylvania Fish and Boat Commission (PFBC), and New York State Department of Environmental Conservation (NYSDEC). Water quality profiles (n=28) and zooplankton samples (n=56) were also collected for hypoxia databases maintained by the U.S. Environmental Protection Agency (EPA) and Cornell University. 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 and several tributaries, supporting multiple coordinated telemetry investigations.

Lake Trout investigations included acoustic telemetry of spawning migration and habitat use in coordination with OMNRF, NYSDEC, and PFBC. Results from Lake Trout investigations will be reported in the Coldwater Task Group annual report to the Great Lakes Fishery Commission (GLFC) and the CLC. Likewise, interagency forage fish assessments conducted with hydroacoustics will be summarized and reported in the Forage Task Group annual report. Task group reports for 2020-2021 will be available upon completion at: http://www.glfc.org/lake-erie-committee.php.

This report presents biomass-based summaries of fish communities in western Lake Erie derived from USGS bottom trawl surveys conducted from 2013 to 2020 during June and September. The survey design provided temporal and spatial coverage that did not exist in the 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 (Keretz et al. 2021). Annual survey data are added to these sources as the data become available.

## Introduction

Lake Erie has the most populated watershed of all the Great Lakes, and as such has undergone dramatic anthropogenic changes. Since the 1800s, stressors such as overexploitation of fish populations, habitat destruction, exotic species introduction, industrial contamination, and changes in nutrient loading have resulted in substantial changes affecting the fish community. The most notable change has been declines in or extirpation of many native species (Hartman 1973; Leach & Nepszy 1976; Ludsin et al. 2001). The implementation of the Clean Water Act and Great Lakes Water Quality Agreement in the 1970s lead to improved habitat conditions for fish (Reutter 2019), which in part resulted in several strong percid year-classes (e.g. Walleye Task Group 2019). These strong year-classes also may have benefited from more restrictive management that reduced harvest and may have ultimately rehabilitated Lake Erie percid stocks (Vandergoot et al. 2006).

Recently updated FCOs set forth a vision that “Lake Erie will consist of diverse fish communities that support ongoing societal benefits, including thriving commercial and recreational fisheries, improved fish habitat and desirable ecosystem performance, and reduced adverse impacts from invasive fish” (Francis et al. 2020). Historically, Lake Erie supported a cool water fish community dominated by percids and salmonids. Today, mixed fisheries resulting from seasonally changing cool and warm water habitats have developed in Lake Erie, and the new FCO’s reflect the desire to manage both predator and prey communities within them.

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 direct measurements of biomass. Therefore, our understanding of fish community structure and ecosystem dynamics from mass-based 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/; Keretz et al. 2021) or obtained for earlier years (https://doi.org/10.5066/F75M63X0; U.S. Geological Survey, Great Lakes Science Center 2019). The purpose of this report is 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 summarize survey results for the most recent series of West Basin trawl data from 2013 through 2020.

## Methods

### *Survey Area and Sampling Design*

During 2013-2020, 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).

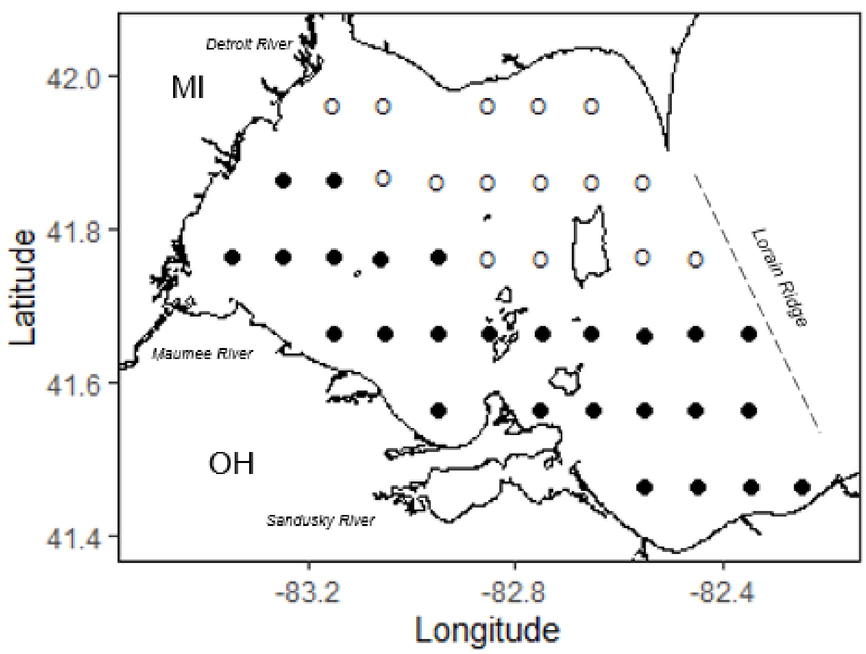


**Figure 1.** Target bottom trawl locations in the West Basin of Lake Erie sampled by U.S. Geological Survey Lake Erie Biological Station. Filled circles represent stations sampled in September 2020.

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 (Kelleys Island, Pelee Island, the Bass Islands, and several smaller 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. Sampling in 2020 was restricted to September and US waters only due to the SARS-CoV-2 pandemic.

The 2020 autumn survey took place during the week of September 15. We trawled a total area of 16.8 hectares and caught a total fish biomass of 777 kg (10,551 fish; 18 species).

***Trends in Biomass and Community Composition***

Total biomass in trawl catches declined by approximately 85 percent from 310 kg/ha in 2013 to 99 kg/ha in 2020 (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:** Spring (June) and Autumn (September) survey summaries of catch (kg/ha) for total and forage species (± SD), 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 |
| 2020 | Spring | 0 | – | – | – | – |
| 2020 | Autumn | 26 | 99 ± 117 | 18.5 ± 71.96 | 0.12 | 0.74 |

Forage biomass averaged 18.4 kg/ha in 2020 during autumn sampling (Table 1). Catches of forage fish were dominated by Gizzard Shad in Autumn 2020 after relatively low catches of the species throughout the survey (Figure 2). Emerald Shiner catches peaked at 51.5 kg/ha in spring 2013 and were <0.1 kg/ha in autumn 2020 (Figure 2). During 2013-2020, Rainbow Smelt catches have been low and varied from <0.01 kg/ha to 0.11 kg/ha (Figure 2).

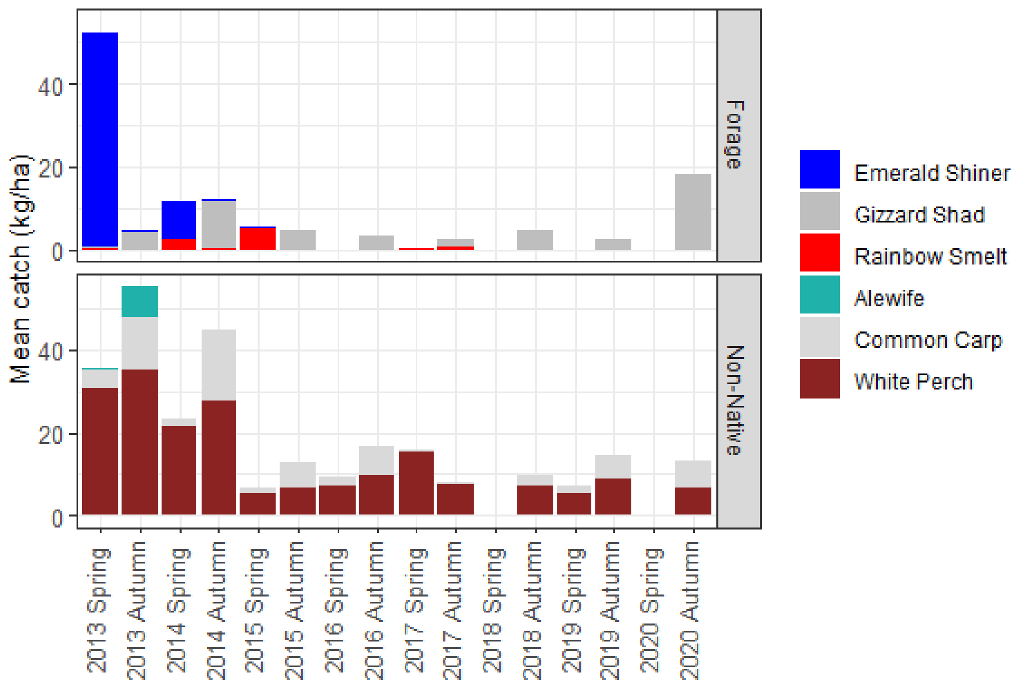


**Figure 2.** Stacked area plots of catch of primary forage (upper panel) and non-native (lower panel) fishes from trawls in the West Basin of Lake Erie in spring (June) and Autumn (September) (No sampling occurred in spring season of 2018 & 2020). Rainbow Smelt belong to both categories but are only 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 catch of non-native species was generally less than 0.25, averaging 0.15 ± 0.05 (mean ± SD) over the eight years (Table 1). The dominant non-native species either declined or showed little evidence of trends. White Perch averaged 12.32 ±

27.95 kg/ha across the series, with catch rates of 6.73 kg/ha in autumn of 2020 (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 = 4.29 ± 4.78 kg/ha; Figure 2) during 2013-2020. 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 2014-2020 (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).

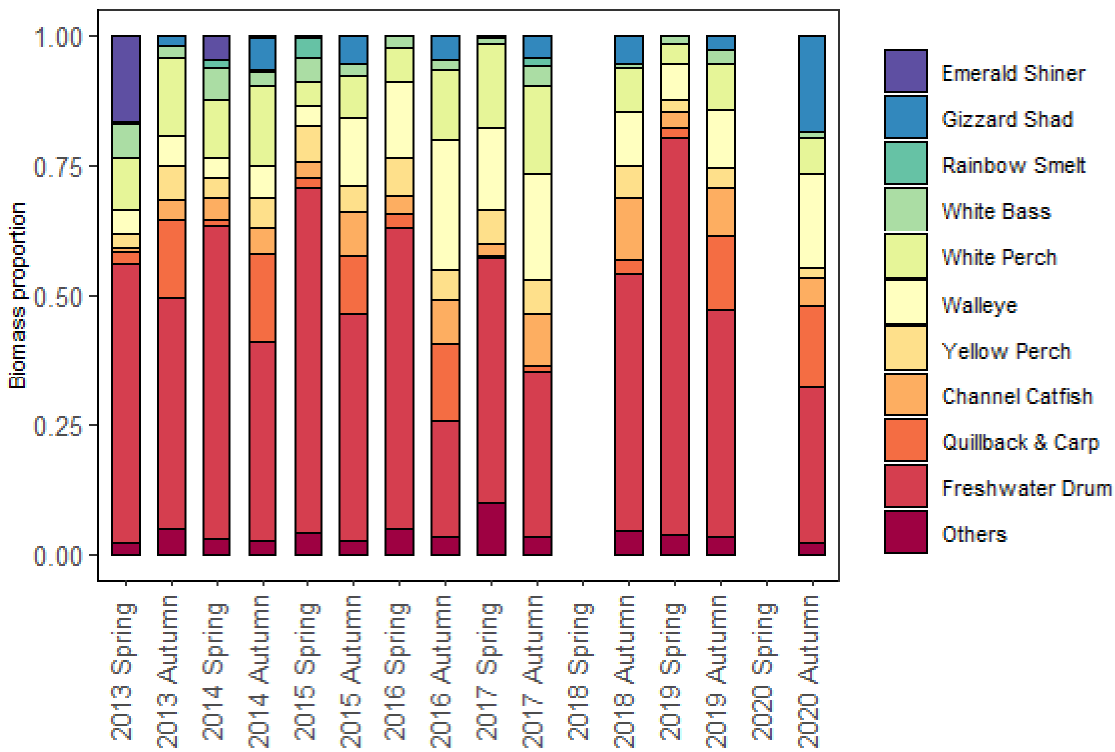


**Figure 3.** Biomass proportion of fish species in bottom trawls in the West Basin of Lake Erie conducted in spring (June) and autumn (September).

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/; Keretz et al. 2021).

Freshwater Drum biomass proportion was slightly under the autumn average with percentages approaching 30% in Autumn 2020 (Figure 3). Although it has remained the dominant single species by biomass (except in autumn 2016), Freshwater Drum biomass has fluctuated from 25% to 80% over the last eight years. 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% ± 1.16% prior to 2015 to 13.59% ± 5.92% of the catch biomass in recent years (Figure 3). The proportion of Gizzard Shad in 2020 was relatively high (19%) compared to the previous 7 years of sampling (~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 catch rates in autumn 2020 remained low (19.96 fish/ha) after a modest increase in autumn 2018 (Figure 4). A larger peak in catch rates was observed for age-0 Yellow Perch in 2014, and although we expected a corresponding peak in age-1 catch rates one year later, the data did not support this prediction (Figure 4). By comparison for Walleye, a lagged year-class signal was evident in age-0 and age-1 catch rate peaks corresponding to the 2015 year-class (age-0 = 69.67 fish/ha; Figure 4). A similar pattern was observed between the increase in Walleye age-0 catch rates from 2018 to 2019 and the increase in age-1 catch rates from 2019 to 2020. After survey-high catches of age-0 Walleye in 2019 (95.21 fish/ha), catch rates dropped to below 20 fish/ha in autumn 2020.

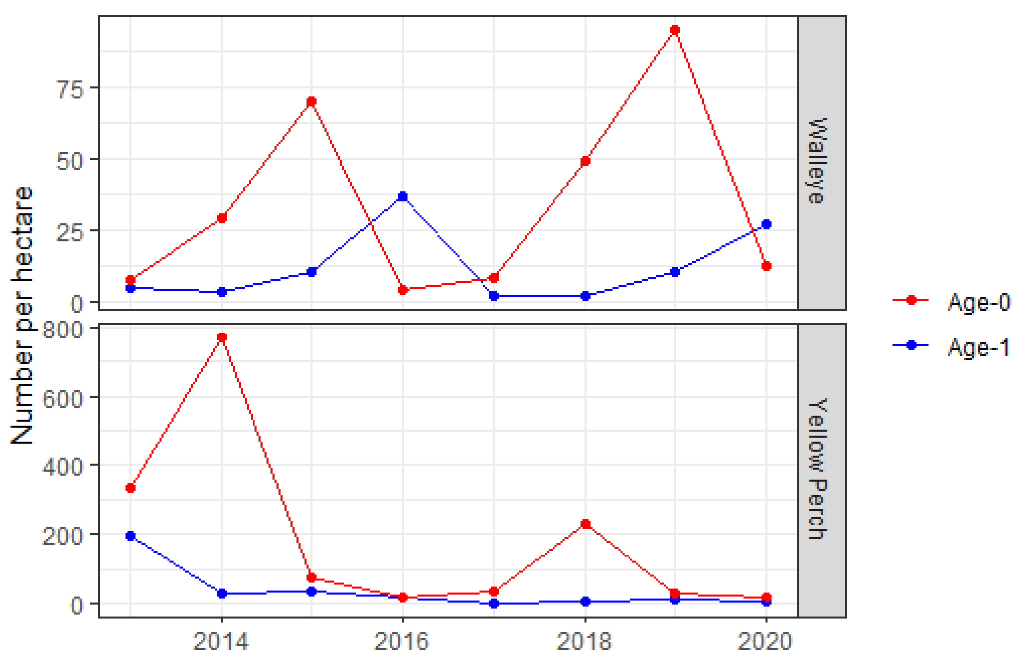

**Figure 4.** Mean number per hectare of age-0 and age-1 Walleye (upper panel) and Yellow Perch (lower panel) in bottom trawls from autumn sampling in the West Basin of Lake Erie.

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## Summary

Although biomass of bottom trawl catches from the West Basin of Lake Erie has declined dramatically over the past eight years, cycles of fish population abundance are often longer than eight years in the Laurentian Great Lakes (USGS 2014). Thus, trends from an eight-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 diverse fish communities that support Lake Erie Fish Community Objectives, including thriving commercial and recreational fisheries, improved fish habitat and desirable ecosystem performance, and reduced adverse impacts from invasive fish (Francis et al. 2020). Notably, the importance of Freshwater Drum may be underemphasized if Lake Erie surveys 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 in the West Basin (Knight et al. 1984). Particularly for Walleye, which have experienced strong year-classes in 2015, 2018, and 2019, the higher abundance of Gizzard Shad is encouraging. However, the inconsistent abundance of forage in the West Basin of Lake Erie over the last several years may result in a pattern of 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.

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