# Fisheries Research and Monitoring Activities of the Lake Erie Biological Station, 2021[1]

Prepared by (in alphabetical order)

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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 gibbosus* | Pumpkinseed | *Percopsis omiscomaycus* | Trout-perch |
| *Lepomis macrochirus* | Bluegill | *Salvelinus namaycush* | Lake Trout |
| *Lota lota* | Burbot | *Sander vitreus* | Walleye |
| *Macrhybopsis storeriana* | Silver Chub | | |

**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 Objectives (FCOs) developed in 2020 (Francis et al. 2020). The 2020 U.S. Geological Survey (USGS) Lake Erie Biological Station annual report is responsive to these FCOs and the USGS obligations via a Memorandum of Understanding (MOU) in 2004 with the Great Lakes Fishery Commission (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 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 2021 deep water science fieldwork began in Lake Erie in March and concluded in December, utilizing trawl, gill net, hydroacoustic, lower trophic sampling, and telemetry methods. This work resulted in 67 bottom trawls covering 40.9 ha of lake-bottom and catching 28,306 fish totaling 3,438 kg in the West Basin of Lake Erie. Overnight gill net sets (n=34) for cold water species were performed in the West and East basins of Lake Erie. A total of 6.2 km of gillnet was deployed during these surveys, which caught 177 fish, 138 of which were native cold-water species: Lake Trout, Burbot, Cisco, and Lake Whitefish. USGS hydroacoustic surveys produced 215 km of transects, and lower trophic sampling provided data from zooplankton samples (n=27) and water quality profiles (n=27) to populate a database maintained by the Michigan Department of Natural Resources (MDNR), Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry (OMNDMNRF), 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=75) were also collected to populate hypoxia databases maintained by the U.S. Environmental Protection Agency (EPA). USGS also assisted

CLC member agencies with deployment and maintenance of Great Lakes Acoustic Telemetry Observation System (GLATOS) infrastructure throughout all three Lake Erie basins and tributaries, supporting multiple coordinated telemetry investigations.

Lake Trout investigations included acoustic telemetry of spawning migration and habitat use in coordination with OMNDMNRF, NYSDEC, and PFBC. Results from Lake Trout investigations will be reported in the Coldwater Task Group annual report to the 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 2021-2022 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 2021 during June and September. The survey design provided temporal and spatial coverage that does not exist in the interagency trawl database, and thus complemented the August ODNR- OMNDMNRF 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. 2022). Annual survey data are added to these sources as 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 (Vandergoot et al. 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. 2019). 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 FCOs 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. 2022) 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 2021.

## Methods

### *Survey Area and Sampling Design*

During 2013-2021, 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 OMNDMNRF 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).

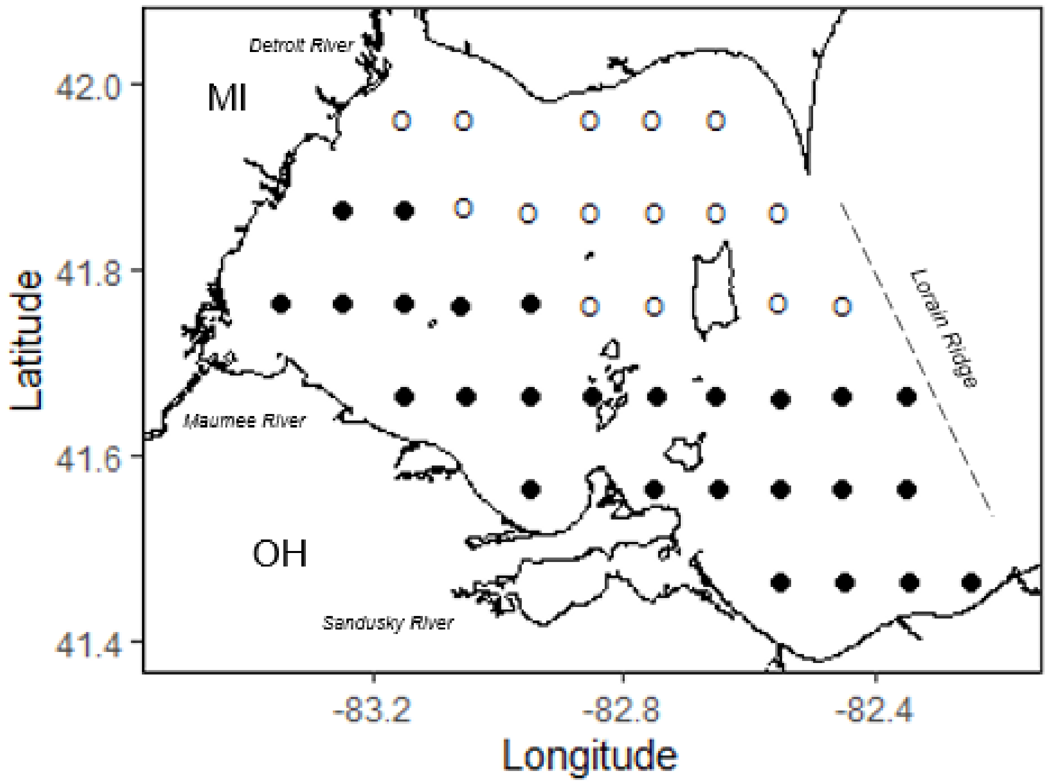


**Figure 1.** Target bottom trawl locations sampled by U.S. Geological Survey Lake Erie Biological Station. All stations were sampled in June 2021. Filled circles represents stations sampled in September 2021.

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. All 41 stations were sampled in June 2021; however, stations were restricted to US waters only again due to the SARS-CoV-2 pandemic in September 2021.

**Results and Discussion**

The 2021 spring and autumn surveys took place during the weeks of June 21 and September 13, respectively. All 41 stations were sampled in spring 2021, trawling a total area of 25 hectares. Autumn sampling consisted of only 26 stations (15.9 ha) in US waters due to restrictions associated with the SARS-CoV-2 pandemic. Surveys caught a total fish biomass of 3,438 kg (28,306 fish), with spring catches totaling 2,221 kg (13,162 fish from 18 species) and autumn catches totaling 1,217 kg (15,143 fish from 21 species).

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

Total biomass in trawl catches declined by approximately 75 percent from 307 kg/ha in 2013 to 78 kg/ha in 2021 (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 Shiner, 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 | 0.21 |
| 2013 | Autumn | 41 | 235 ± 154 | 4.9 ± 8.98 | 0.24 | 1.78 |
| 2014 | Spring | 41 | 194 ± 173 | 11.8 ± 25.75 | 0.13 | 0.73 |
| 2014 | Autumn | 41 | 178 ± 113 | 12.2 ± 21.04 | 0.25 | 1.58 |
| 2015 | Spring | 41 | 122 ± 100 | 5.4 ± 19.22 | 0.10 | 0.99 |
| 2015 | Autumn | 41 | 86 ± 66 | 4.9 ± 5.79 | 0.15 | 1.52 |
| 2016 | Spring | 41 | 101 ± 75 | 0.1 ± 0.12 | 0.09 | 1.17 |
| 2016 | Autumn | 41 | 74 ± 57 | 3.5 ± 6.35 | 0.22 | 1.96 |
| 2017 | Spring | 36 | 96 ± 69 | 0.4 ± 1.08 | 0.17 | 1.66 |
| 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 | 1.84 |
| 2019 | Spring | 41 | 136 ± 108 | 0.1 ± 0.20 | 0.05 | 1.47 |
| 2019 | Autumn | 41 | 96 ± 102 | 2.6 ± 3.70 | 0.15 | 1.83 |
| 2020 | Spring | 0 | – | – | – | – |
| 2020 | Autumn | 26 | 99 ± 117 | 18.5 ± 71.96 | 0.12 | 0.74 |
| 2021 | Spring | 41 | 93 ± 93 | 0.1 ± 0.22 | 0.04 | 1.30 |
| 2021 | Autumn | 26 | 78 ± 41 | 2.4 ± 4.02 | 0.12 | 1.77 |

Forage biomass averaged 2.4 kg/ha in 2021 during autumn sampling (Table 1). Emerald Shiner catches peaked at 51.5 kg/ha in spring 2013 and were <0.1 kg/ha in autumn 2021 (Figure 2). During 2013-2021, Rainbow Smelt catches have been low and varied from <0.01 kg/ha to 0.11 kg/ha (Figure 2). Catches of Gizzard Shad decreased in autumn 2021 (2.38 kg/ha) after relatively high catches of the species in autumn 2020 (Figure 2).

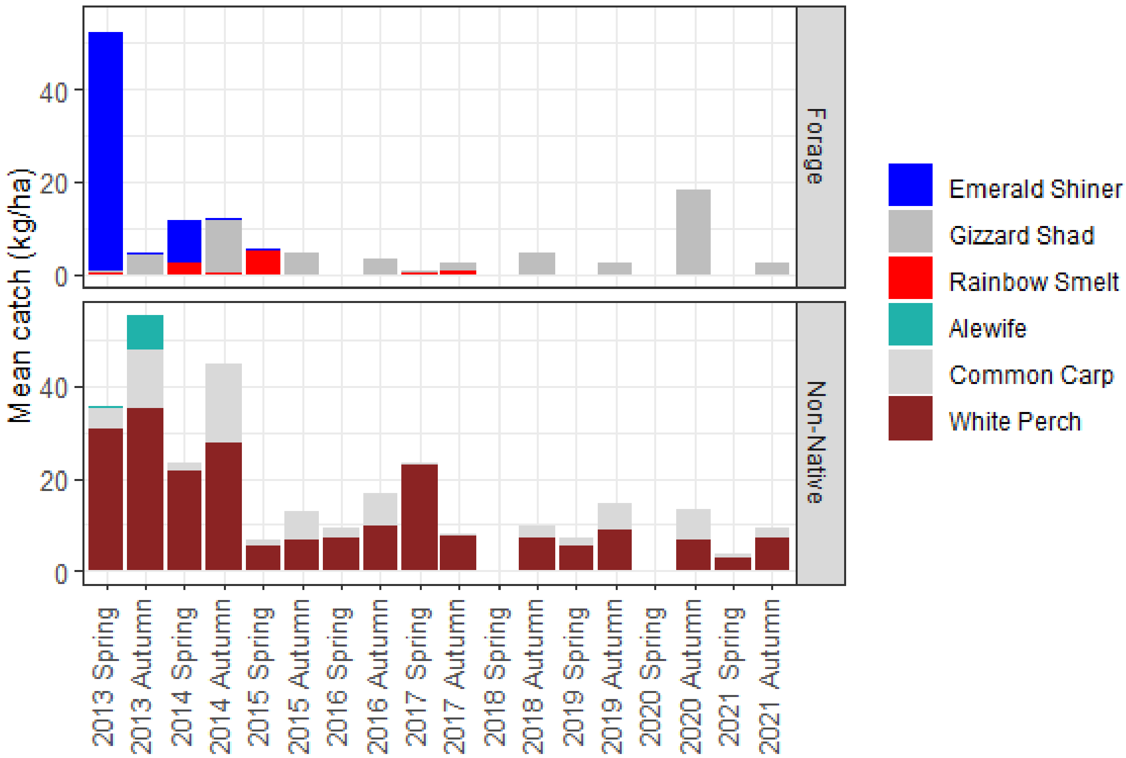


**Figure 2.** Stacked area plots of catch of primary forage (upper panel; Emerald Shiner, Gizzard Shad, and Rainbow Smelt) and non-native (lower panel; Alewife, Common Carp, and White Perch) fishes from trawls in the West Basin of Lake Erie in spring (June) and autumn (September). No sampling occurred in spring season of 2018 and 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 non-native species proportion of total biomass was generally less than 25%, averaging 15% ± 5% (mean ± SD) between 2013 and 2021 (Table 1). The dominant non-native species biomass 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 2021 (Figure 2). Common Carp contributed the second highest biomass for non-native species varying from 0.38 to 17.02 kg/ha (mean = 4.29 ± 4.78 kg/ha; Figure 2) during 2013-2021. After relatively large mean biomass of Alewife in 2013 (0.69 kg/ha and 7.69 kg/ha in spring and autumn, respectively), very low (<0.01 kg/ha) to zero biomass was captured during 2014-2021 (Figure 2). Other non-native species (Round Goby, Goldfish, Sea Lamprey) contributed little biomass (<0.1 kg/ha) during annual surveys.

Despite the decrease in total biomass, biodiversity of trawl catches was variable and ranged from 0.73 to 1.96 (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 occurred, due to the presence of one additional species (Lake Whitefish) in spring catches (Table 1).

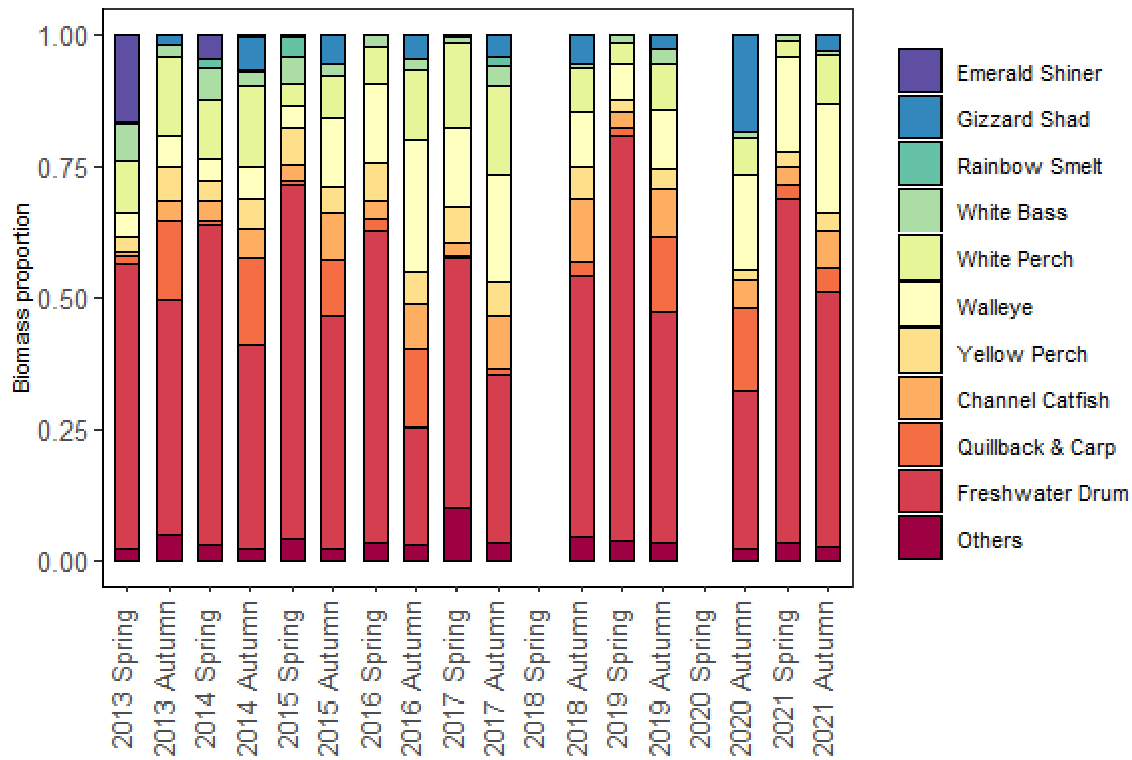


**Figure 3.** Biomass proportion of fish species in bottom trawls in the West Basin of Lake Erie conducted in spring (June) and autumn (September).

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. 2022).

Freshwater Drum biomass proportion was near the autumn average with percentages approaching 50% in autumn 2021 (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 five years (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 5.1% (s.d. = 1.2) prior to 2015 to 14.6% (s.d. = 5.9) of the catch biomass in recent years (Figure 3). After a relatively high proportion in autumn 2020 (19%), Gizzard Shad declined to near average levels for the series (~5-10%). Contributions from other forage species (Emerald Shiner and Rainbow Smelt) to total biomass remained below 5%.

***Trends in Percids***

Age-0 Yellow Perch catch rates in autumn 2021 were highest since 2018 (101 fish/ha) (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 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 relatively low catches of age-0 Walleye in 2020 (13 fish/ha), catch rates increased to 33 fish/ha in autumn 2021.

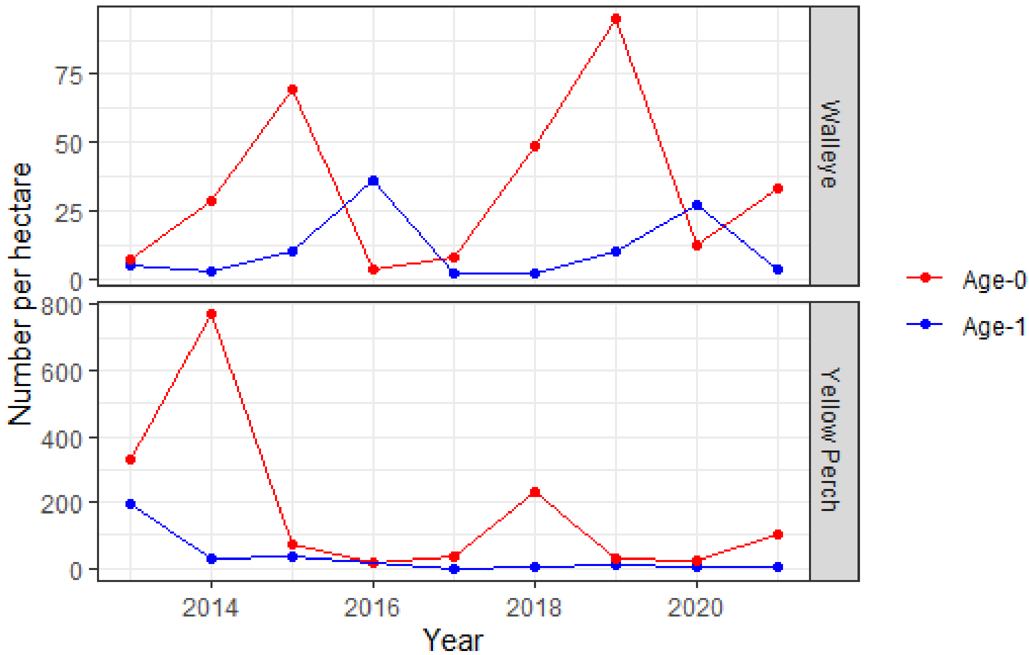


**Figure 4.** Mean number per hectare of age-0 and age-1 Walleye (upper panel) and Yellow Perch (lower panel) in bottom trawls from western Lake Erie during autumn.

**Summary**

Although biomass of bottom trawl catches from the West Basin of Lake Erie have declined dramatically over the past nine years, cycles of fish population abundances and community dynamics often occur over longer time frames in the Laurentian Great Lakes (USGS 2014). Thus, trends from a nine-year data series should be interpreted cautiously. Fish biomass estimates collected during this survey may provide important information on fish community and ecosystem structure in Lake Erie not immediately available from existing numerical based monitoring efforts.  Notably, the role that Freshwater Drum play in community dynamics 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 non-native 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 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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