Fisheries Research and Monitoring Activities of the Lake Erie Biological Station, 2023[1]

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[1] LEBS 2024. Fisheries Research and Monitoring Activities of the Lake Erie Biological Station, 2023. Prepared by Mark R. DuFour, Francesco Guzzo, Corbin D. Hilling, Kevin R. Keretz, Richard T. Kraus, Richard C. Oldham, James J. Roberts, and Joseph D. Schmitt. Report of the Lake Erie Biological Station (LEBS) to the Great Lakes Fishery Commission at the Annual Meeting of Lake Committees, Bay City, MI 13 pp.

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 nigricans*	Largemouth Bass
Alosa pseudoharengus	Alewife	*Morone americana*	White Perch
Ambloplites rupestris	Rock Bass	*Morone chrysops*	White Bass
Ameiurus nebulosus	Brown Bullhead	*Moxostoma anisurum*	Silver Redhorse
Aplodinotus grunniens	Freshwater Drum	*Moxostoma erythrurum*	Golden Redhorse
Carassius auratus	Goldfish	*Moxostoma macrolepidotum*	Shorthead Redhorse
Carpiodes cyprinus	Quillback	*Neogobius melanostomus*	Round Goby
Catostomus commersonii	White Sucker	*Notemigonus crysoleucas*	Golden Shiner
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	*Oncorhynchus mykiss*	Rainbow Trout
Ictalurus punctatus	Channel Catfish	*Perca flavescens*	Yellow Perch
Labidesthes sicculus	Brook Silverside	*Petromyzon marinus*	Sea Lamprey
Lepisosteus osseus	Longnose Gar	*Percina caprodes*	Logperch
Lepomis gibbosus	Pumpkinseed	*Percopsis omiscomaycus*	Trout-perch
Lepomis macrochirus	Bluegill	*Pomoxis annularis*	White Crappie
Lota lota	Burbot	*Salvelinus namaycush*	Lake Trout
Macrhybopsis storeriana	Silver Chub	*Sander vitreus*	Walleye
Micropterus dolomieu	Smallmouth Bass		

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 2023 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 track 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 2023 deep water science fieldwork began in Lake Erie in March and concluded in December, using trawl, gill net, hydroacoustic, lower trophic sampling devices, and telemetry methods. This work resulted in 82 bottom trawls covering 57 ha of lake-bottom and catching 59,626 fish totaling 5,368 kg in the West Basin of Lake Erie. Overnight gill net sets (n=25) for cold water species were performed in the East Basin of Lake Erie. A total of 4.5 km of gillnet was deployed during these surveys, which caught 115 fish, 66 of which were native cold-water species: Lake Trout, Burbot, and Lake Whitefish. Results from cold water species assessments will be reported in the Coldwater Task Group report to the GLFC and the CLC (CTG 2024). USGS hydroacoustic sampling included 24, 5-km transects (120 km total) in the Central Basin as part of a collaborative lake-wide survey with details and results reported by the Forage Task Group (FTG 2024). The R/V Muskie participated in a region-wide effort to explore bias in hydroacoustic sampling due to vessel avoidance by fishes. This sampling effort included 14, ~2-km transects paired with an autonomous wind-powered surface drone. The Pennsylvania Fish and Boat Commission (PFBC) had vessel issues, so the R/V Muskie assisted with their autumn trawl survey by completing 15 bottom trawls in the vicinity of Erie, Pennsylvania during October 2023. Lower trophic sampling provided data from zooplankton samples (n=15) and water quality profiles (n=15) to populate a database maintained by the Michigan Department of Natural Resources (MDNR), Ontario Ministry of Natural Resources and Forestry (OMNRF), Ohio Department of Natural Resources (ODNR), PFBC, and New York State Department of Environmental Conservation (NYSDEC). 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.

This report presents biomass-based summaries of fish communities in western Lake Erie derived from USGS bottom trawl surveys conducted in June and September from 2013 to 2023. The survey design complements the August ODNR- OMNRF effort by adding information for robust stock assessment. 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. 2024). 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 proliferation, 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; 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. 2010). These strong year-classes also may have benefited from more restrictive management practices that reduced harvest and may have ultimately rehabilitated Lake Erie percid stocks (Kayle et al. 2015; STC 2020). 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 Lake Trout, Smallmouth Bass, Walleye, Yellow Perch), 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 biomass-based models has been limited to short-term investigations and proxy measurements (e.g., length-weight conversion; Forage Task Group Report 2020).

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 availability of 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 (described in Keretz et al. 2024). As this situation interrupted the existing time series, 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. 2024) 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 2023.

Methods

Survey Area and Sampling Design

During 2013–2023, 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 Pelee-Lorain Ridge, which acts as a natural boundary between the relatively shallow West Basin and deeper Central Basin (Figure 1).

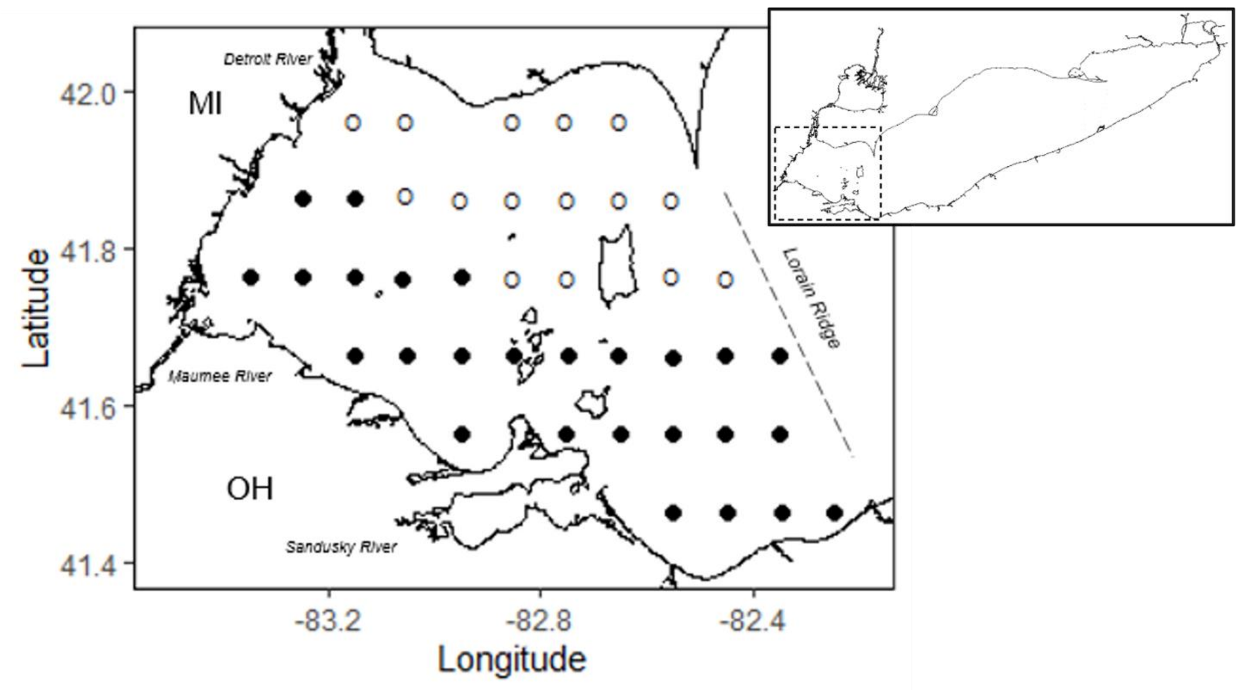

Figure 1. *Target bottom trawl locations sampled by U.S. Geological Survey Lake Erie Biological Station. Open circles represent stations located in Ontario, Canada waters, whereas closed circles represent stations in United States waters.*

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 the West Basin of Lake Erie, which included areas of the main basin, Lake Erie Islands (Kelleys Island, Pelee Island, North Bass, Middle Bass, South Bass, 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). 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 ships 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 U.S. waters only due to the SARS-CoV-2 pandemic. All 41 stations were sampled in June 2021; however, stations were restricted to U.S. waters only due to restrictions related to the SARS-CoV-2 pandemic in September 2021. Surveys were completed (N=41) in all other years and seasons.

Results and Discussion

The 2023 spring survey took place during the week of June 20. Autumn sampling took place during the week of September 18. All 41 stations were sampled during both spring and autumn efforts. Surveys caught a total fish biomass of 5,368 kg (59,626 fish), with spring catches totaling 2,272 kg (9,952 fish) and autumn catches totaling 3,096 kg (49,674 fish).

Trends in Biomass and Community Composition

Total biomass in trawl catches declined by nearly 90 percent from 347 kg/ha in 2013 to 55 kg/ha in 2017 (Figure 2; 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). Catches have since stabilized with biomass estimates ranging from 78–139 kg/ha between 2018–2023.

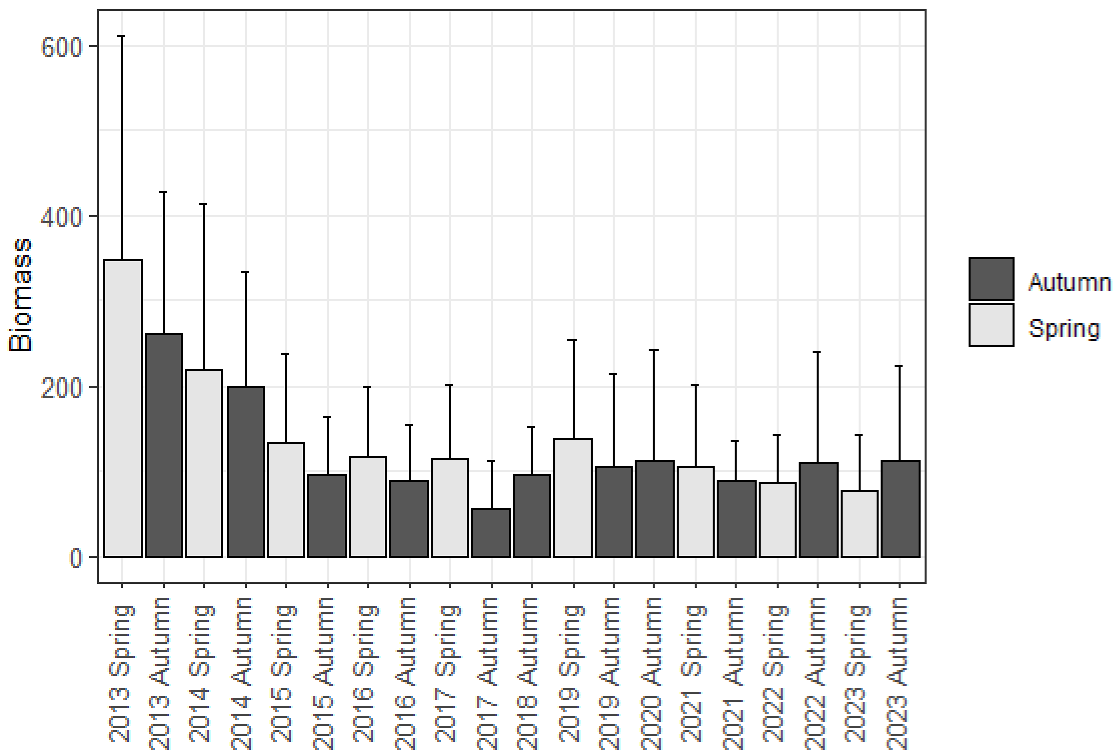

Figure 2. *Mean catch (kg/ha) for total species (± s.d.) in bottom trawls in the West Basin of Lake Erie conducted in spring (June) and autumn (September) (No sampling occurred in spring season of 2018 & 2020).*

Primary forage biomass averaged 12.5 kg/ha in 2023 during autumn sampling (Table 1). Increased forage biomass can be attributed to record catches of Alewife for the survey (8.96 kg/ha; Figure 3). Very few (<0.05 kg/ha) to no Alewife had been captured from 2014–2022 after large mean catches in autumn 2013 (7.69 kg/ha; Figure 3). Emerald Shiner catches peaked at 51.5 kg/ha in spring 2013 and were <0.1 kg/ha in autumn 2023 (Figure 3). Relatively large Rainbow Smelt catches ranging from 0.7–5.0 kg/ha prior to 2017 were followed by low and varied catches from <0.01 kg/ha to 0.32 kg/ha for the rest of the survey (Figure 3). Autumn catches of Gizzard shad have stabilized near the average for the survey after relatively high catches of the species in autumn 2020 (18.39 kg/ha; Figure 3).

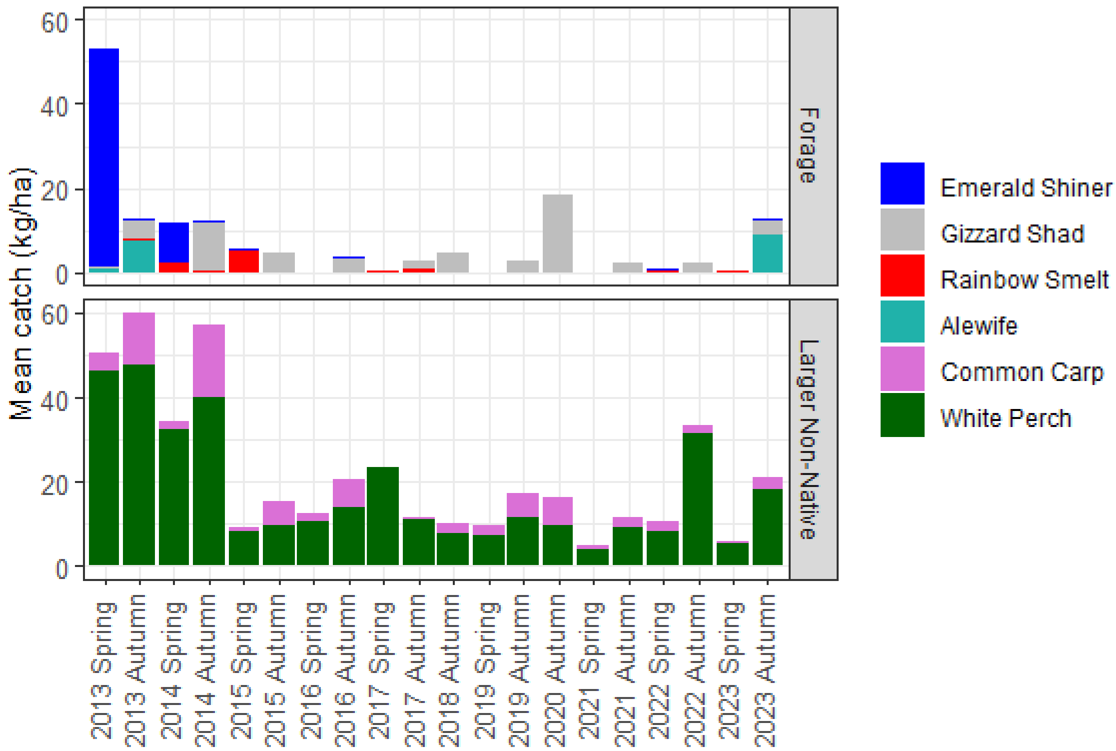

Figure 3. *Stacked area plots of catch of primary forage (upper panel) and non-native (lower panel) fishes from trawls in the West Basin of Lake Erie in spring (June) and autumn (September) (No sampling occurred in spring season of 2018 & 2020). Rainbow Smelt and Alewife are non-native but are only plotted in the upper panel to help visualize estimates for forage fish abundance. 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 proportion of non-native species biomass was generally less than 0.25, averaging 0.15 ± 0.07 (mean ± SD) over the eleven-year sampling period (Table 1). The dominant non-native species biomass either declined or showed little evidence of trends. After Alewife, White Perch (18.41 kg/ha) and Common Carp (2.74 kg/ha) accounted for the highest non-native species biomass during autumn sampling in 2023 (Figure 3). Other non-native species (Round Goby, Goldfish, Sea Lamprey) accounted for little biomass (<0.1 kg/ha) during annual surveys.

Despite the decrease in total biomass, biodiversity of trawl catches was variable and ranged from 0.14 to 1.77 (Shannon Diversity Index; Morris et al. 2014, Table 1). Diversity tended to be higher in autumn than spring, except in 2017 and 2023 when the opposite pattern was due to the presence of rare species accompanied by low overall catch rates (Table 1).

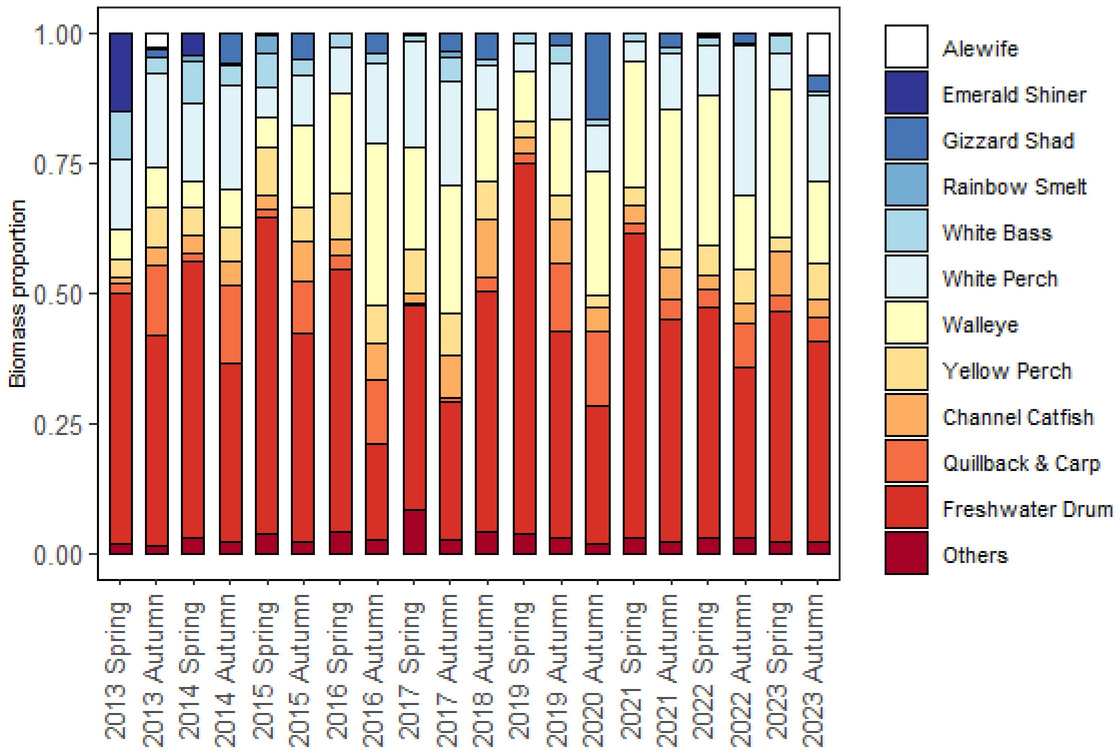

Figure 4. *Proportion of fish species biomass in bottom trawls in the West Basin of Lake Erie conducted in spring (June) and autumn (September).*

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. 2024).

Freshwater Drum biomass proportion was near the autumn average with percentages approaching 50% in autumn 2023 (Figure 4). Although it has remained the dominant species by biomass (except in autumn 2016), Freshwater Drum biomass has fluctuated from 25% to 80% over the last six years (Figure 4). 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 4). 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 5.05% (s.d. = 1.16) prior to 2015 to 15.56% (s.d. = 5.93) of the catch biomass in recent years (Figure 4). After a relatively high proportion in autumn 2020 (19%), Gizzard shad declined to near average levels for the series (~5-10%).

Alewife composed 13% of catches while contributions from other forage species (Emerald Shiner, Rainbow Smelt) remained below 5%.

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

Year	Season	n	Total	Forage	Non-Native Proportion	Shannon Diversity
2013	Spring	41	347 ± 265	52.9 ±111.26	0.15	0.14
2013	Autumn	41	261 ± 166	12.5 ± 28.62	0.26	1.68
2014	Spring	41	219 ± 193	11.8 ± 25.75	0.17	0.65
2014	Autumn	41	200 ± 133	12.2 ± 21.03	0.29	1.42
2015	Spring	41	134 ± 104	5.4 ± 19.22	0.11	0.93
2015	Autumn	41	95 ± 68	4.9 ± 5.79	0.16	1.29
2016	Spring	41	117 ± 82	0.1 ± 0.12	0.11	1.28
2016	Autumn	41	89 ± 66	3.5 ± 6.35	0.23	1.77
2017	Spring	36	114 ± 87	0.6 ± 1.66	0.21	1.47
2017	Autumn	41	55 ± 56	2.7 ± 4.73	0.22	0.68
2018	Spring	0	–	–	–	–
2018	Autumn	41	95 ± 56	4.7 ± 9.43	0.11	1.60
2019	Spring	41	139 ± 114	0.1 ± 0.24	0.07	1.13
2019	Autumn	41	106 ± 108	2.6 ± 3.67	0.17	1.75
2020	Spring	0	–	–	–	–
2020	Autumn	26	112 ± 130	18.5 ± 71.96	0.15	0.42
2021	Spring	41	105 ± 97	0.1 ± 0.22	0.05	1.68
2021	Autumn	26	89 ± 48	2.4 ± 4.02	0.13	1.61
2022	Spring	41	86 ± 57	0.7 ± 1.63	0.13	1.54
2022	Autumn	41	109 ± 129	2.1 ± 2.90	0.31	1.69
2023	Spring	41	78 ± 66	0.3 ± 2.9	0.08	1.75
2023	Autumn	41	112 ± 111	12.5 ± 47.26	0.27	1.06

Trends in Percids

Age-0 Yellow Perch catch rates in autumn 2023 declined (22 fish/ha) when compared to catches in 2022 (84 fish/ha) (Figure 5). Relatively consistent catches of Age-0 Yellow Perch in 2021 (101 fish/ha) and 2022 corresponded with consistent catches of age-1 Yellow Perch in 2022 (18 fish/ha) and 2023 (13 fish/ha) (figure 5). A lagged year-class signal was also evident in age-0 and age-1 Walleye, with catch rate peaks corresponding to the 2015, 2018, and 2021 year-classes (Figure 5).

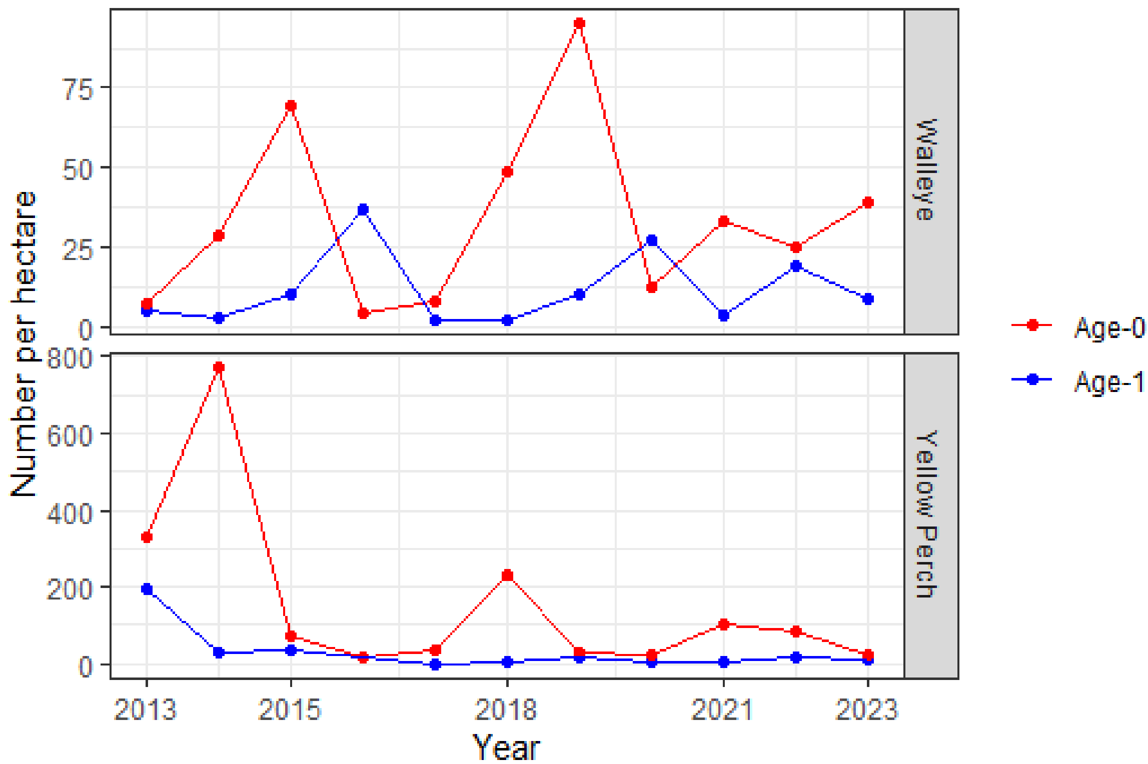

Figure 5. *Mean number per hectare of age-0 and age-1 Walleye (upper panel) and Yellow Perch (lower panel) in bottom trawls from western Lake Erie during autumn.*

Summary

This survey provides 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, desirable ecosystem performance, and reduced adverse impacts from invasive fish (Francis et al. 2020). Notably, this survey complements the time series of combined trawling efforts between ODNR and OMNRF in August, providing spatially contiguous recruitment indices supporting percid harvest management. In addition, this survey's calculation of biomass indicates that numerical catch rates may underestimate the importance of Freshwater Drum in fish community structure. The potential for Freshwater Drum to reduce invasive dreissenid mussel abundance 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). The lack of a consistent forage biomass presented herein, and observed in other surveys lake wide, highlight the need to better understand distribution and mechanisms driving forage fish abundance on a lake-wide scale. Western

Basin Walleye and Yellow Perch have historically relied on Gizzard Shad and Emerald Shiner as primary forage in the West Basin (Knight et al. 1984); however, these fish may seasonally access other parts of Lake Erie. Particularly for the migratory Walleye, which have experienced strong year-classes in 2015 and 2019, the inconsistent abundance of forage in the West Basin, as well as other basins of Lake Erie, over the last several years may result in a pattern of reduced growth and early seasonal 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.

Acknowledgments

We thank C. Adams, J. Boyd, D. Stewart, H. Gill, S. Harris, B. Kohler, A. Landry, G. Rutz, and E. Stegens for assistance in the field. Constructive reviews were provided by Ann Marie Gorman and Olivia Mitchinson. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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