Fisheries Research and Monitoring Activities of the Lake Erie Biological Station, 2022[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 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 2022 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 (H.R. 1023).

The USGS 2022 deepwater 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 56 ha of lake-bottom and catching 50,716 fish totaling 4,585 kg in the West basin of Lake Erie. Overnight gill net sets (n=50) for cold water species were performed in the West and East basins of Lake Erie. A total of 10 km of gillnet was deployed during these surveys, which caught 250 fish, 149 of which were native cold-water species: Lake Trout, Burbot, Cisco, and Lake Whitefish. Results from cold water species assessments will be reported in the Coldwater Task Group report to the GLFC and the CLC (Coldwater Task Group 2023). 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 (Forage Task Group 2023). Lower trophic sampling provided data from zooplankton samples (n=24) and water quality profiles (n=24) 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), Pennsylvania Fish and Boat Commission (PFBC), and New York State Department of Environmental Conservation (NYSDEC). Additionally, water quality profiles along with images of the benthos (n=96) were 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 OMNRF, NYSDEC, and PFBC. Results from Lake Trout investigations will be reported in the Coldwater Task Group annual report to the GLFC and the CLC (Coldwater Task Group 2023). All task group reports for 2022-2023 listed above and throughout this report will be available upon completion at: http://www.glfc.org/lake-erie-committee.php.

This report presents biomass-based summaries of fish communities in the West Basin of Lake Erie derived from USGS bottom trawl surveys conducted from 2013 to 2022 in June and September. The survey design compliments the August ODNR- OMNRF effort by reinforcing 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. 2023). 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; Leach & Nepszy 1976; Ludsin et al. 2001). The implementation of the Clean Water Act (33 U.S.C. §1251) and Great Lakes Water Quality Agreement (33 U.S. Code § 1268) 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. 2006). 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, Standing Technical Committee 2020). Recently updated Fish Community Objectives (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 (e.g., kg/ha). 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 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 interrupted the existing time series, the sampling design was expanded to include greater spatial coverage of West Basin offshore habitats and increased sample size of trawling locations (increase from 25 to 41 stations). 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. 2023) 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 2022.

Methods

Survey Area and Sampling Design

During 2013-2022, 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).

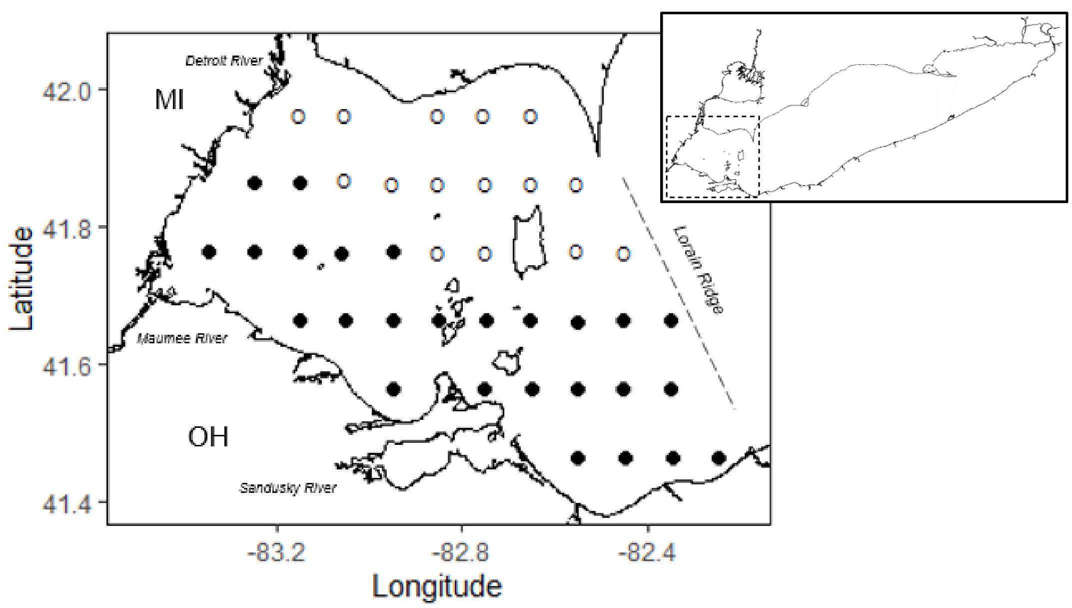

Figure 1. Target bottom trawl locations sampled (41) by U.S. Geological Survey Lake Erie Biological Station between 2013-2022. Filled circles are located in Ohio (OH) and Michigan (MI) waters. Open circles represent stations located in waters within the province of Ontario, Canada.

Sampling locations were selected both to accommodate the trawling net used on the 70-foot, USGS 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, 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 (see Keretz et al. 2023 for locations). 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 the SARS-CoV-2 pandemic in September 2021. All 41 stations were sampled in both June and September 2022.

Results and Discussion

The 2022 spring survey took place during the week of June 21. Autumn sampling took place over a 2-week period from September 13 to 29 due to inclement weather. All 41 stations were sampled during both spring and autumn efforts. Surveys caught a total fish biomass of 4,585 kg (50,716 fish), with spring catches totaling 1,856 kg (20,976 fish) and autumn catches totaling 2,730 kg (29,740 fish).

Trends in Biomass and Community Composition

Total biomass in trawl catches declined by approximately 70 percent from 307 kg/ha in 2013 to 92 kg/ha in 2022 (Table 1; Figure 2). 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: 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 in bottom trawls in the West Basin of Lake Erie conducted in spring (June) and autumn (September), 2013-2022.

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
2022	Spring	41	73 ± 52	0.7 ± 1.63	0.26	1.20
2022	Autumn	41	92 ± 92	2.1 ± 2,90	0.12	1.85

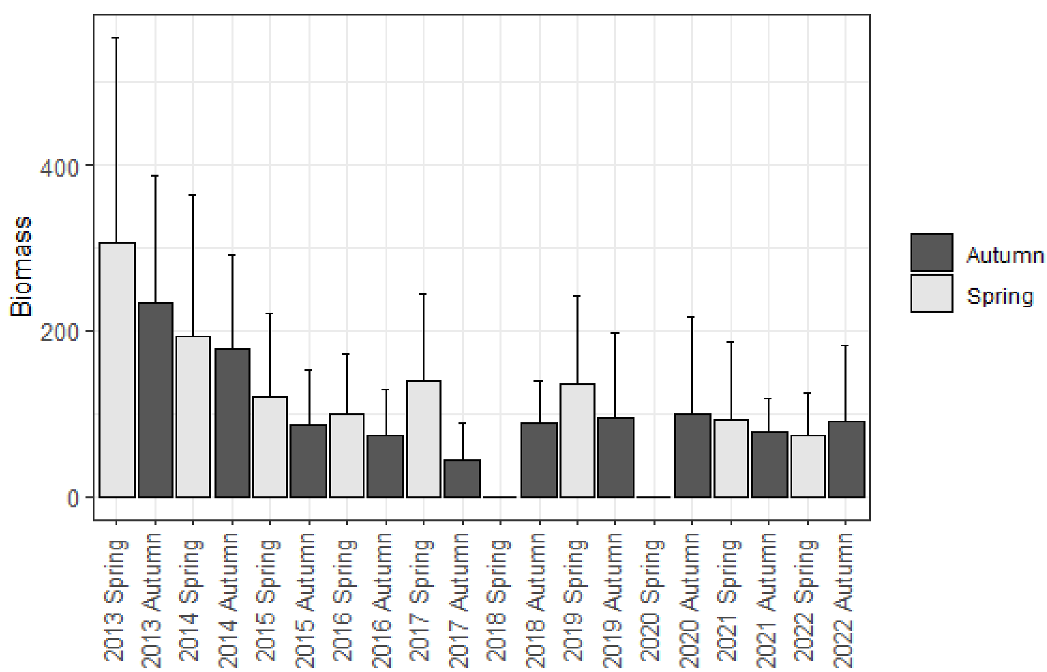

Figure 2. Mean catch (kg/ha) for total species (± s.d.) in bottom trawls in the West Basin of Lake Erie conducted in spring (June) and autumn (September), 2013-2022.

Primary forage biomass averaged 2.1 kg/ha in 2022 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 2022 (Figure 3). During 2013-2022, Rainbow Smelt catches have been low and varied from <0.01 kg/ha to 0.11 kg/ha (Figure 3). Catches of Gizzard shad were again low in autumn 2022 (0.15 kg/ha) after relatively high catches of the species in autumn 2020 (Figure 3).

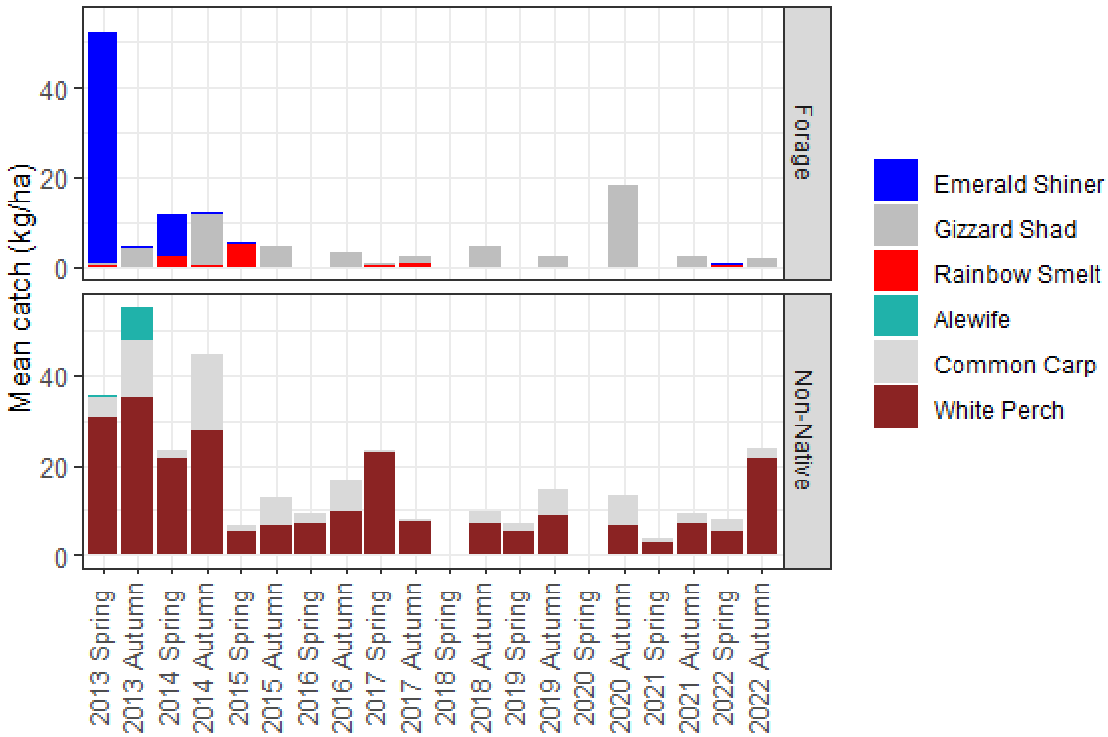

Figure 3. Stacked area plots of catch of primary forage (upper panel) and non-native (lower panel) fishes from trawls in the West Basin of Lake Erie in spring (June) and autumn (September), 2013-2022 (No sampling occurred in spring season of 2018 & 2020). Rainbow Smelt belong to both categories but are 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 ten-year sampling period (Table 1). The dominant non-native species either declined or showed little evidence of trends. White Perch averaged 12.32 ± 32.20 kg/ha across the series, with catch rates of 21.7 kg/ha in autumn of 2022 (Figure 3). Common Carp represented the second most abundant non-native species by biomass and varied from 0.38 to 17.02 kg/ha (mean = 3.82 ± 13.21 kg/ha; Figure 3) during 2013-2022. 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 2014-2022 (Figure 3). 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 0.20 to 1.85 (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).

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 4; numerical versus biomass summaries can be explored here: https://lebs.shinyapps.io/western-basin/; Keretz et al. 2023).

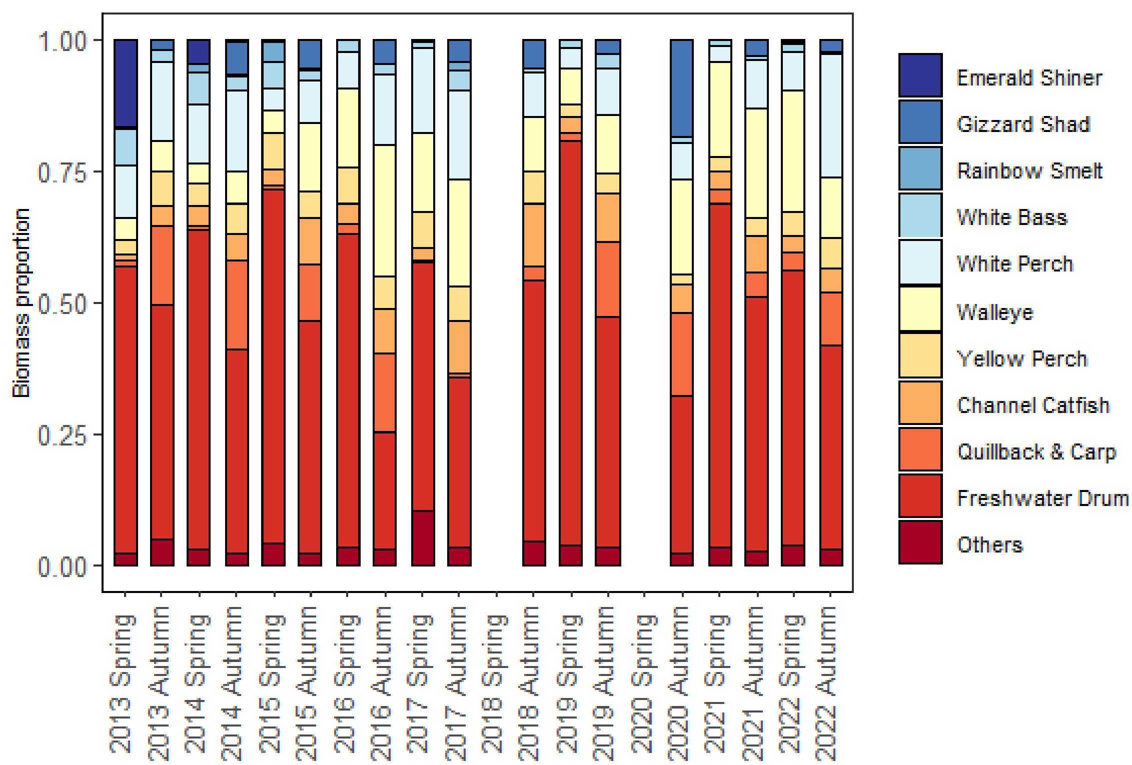

Figure 4. Biomass proportion of fish species in bottom trawls in the West Basin of Lake Erie conducted in spring (June) and autumn (September), 2013-2022.

Freshwater Drum biomass proportion was near the autumn average with percentages approaching 50% in autumn 2022 (Figure 4). 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 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 5.08% (s.d. = 1.16) prior to 2015 to 14.98% (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%). Contributions from other forage species (Emerald Shiner and Rainbow Smelt) remained below 5%.

Trends in Percids

Age-0 Yellow Perch catch rates in autumn 2022 remained relatively high (84 fish/ha), while Age-1 Yellow Perch catch rates increased (18 fish/ha) (Figure 5). Similarly, Age-0 Walleye catch rates remained relatively high (25 fish/ha), while Age-1 Walleye catch rates increased to the third highest density in the time series (19 fish/ha). Throughout the time series, strong Age-0 percid year classes have translated to strong Age-1 index values suggesting healthy recruitment patterns and demonstrating the ability of this survey to capture percid recruitment dynamics. Recruitment indices for these percid species have been submitted to Lake Erie task groups for comparison with indices from other agencies. In general, the patterns were similar, and more detailed analyses can be found in the Yellow Perch and Walleye Task Group annual reports (Walleye Task Group 2023, Yellow Perch Task Group 2023)

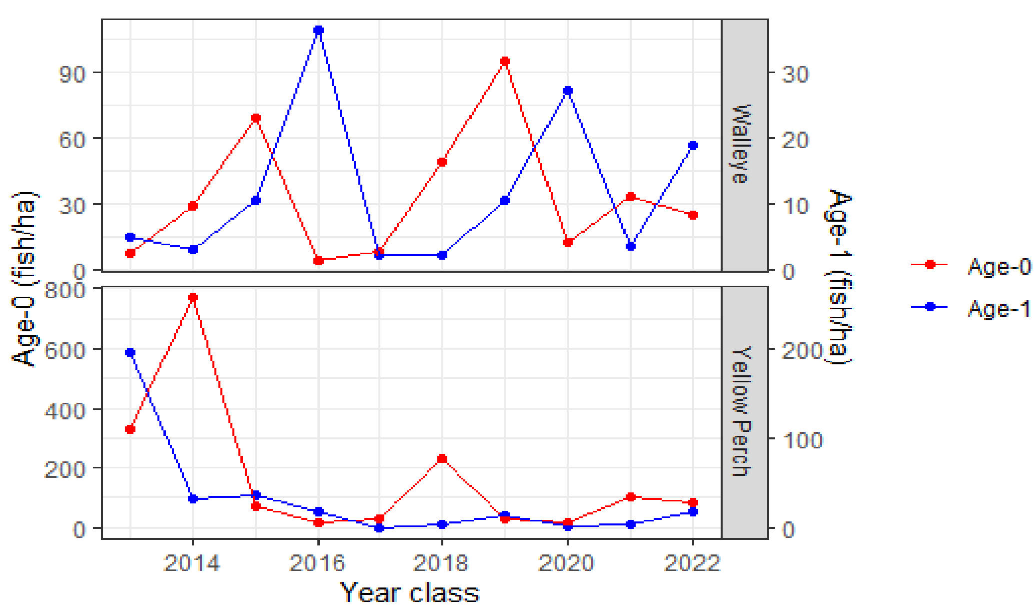

Figure 5. Mean number per hectare of age-0 and age-1 Walleye (upper panel) and Yellow Perch (lower panel) in bottom trawls in the West Basin of Lake Erie conducted in spring (June) and autumn (September), 2013-2022.

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 the importance of Freshwater Drum may be underestimated based on numerical measures of relative abundance compared to those based on biomass. The potential for Freshwater Drum to reduce invasive dreissenid mussel abundance has only been evaluated superficially (French & Bur 1996), but due to the dominance of this species in the fish community, Freshwater Drum may contribute substantially to the remineralization of phosphorous in Lake Erie through the consumption of mussels (e.g., Johnson et al. 2005). The decline in primary 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. West 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 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 would require surveys like the one presented in this report.

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