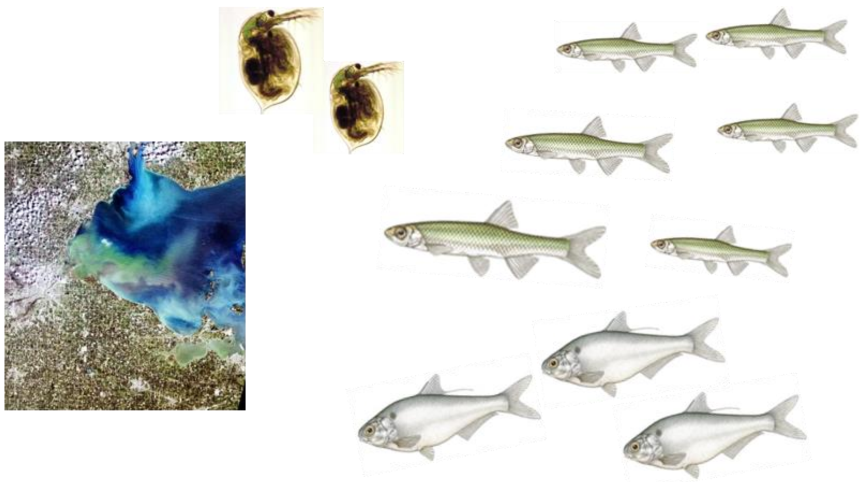
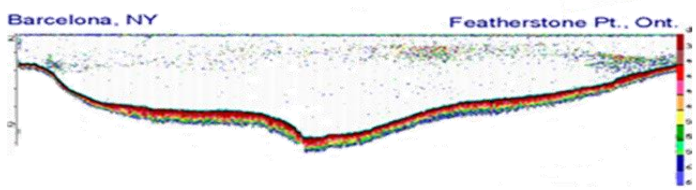
Report of the Lake Erie Forage Task Group

March 2020





Members:

Zak Slagle	- Ohio Department of Natural Resources, (ODNR) {Co-Chair}
Michael Thorn	- Ontario Ministry of Natural Resources and Forestry, (OMNRF) {Co-Chair}
John Deller	- Ohio Department of Natural Resources, (ODNR)
Rebecca Dillon	- United States Geological Survey - Great Lakes Science Center, (USGS)
Jan-Michael Hessenauer	- Michigan Department of Natural Resources, (MDNR)
Mike Hosack	- Pennsylvania Fish and Boat Commission, (PFBC)
Patrick Kočovský	- United States Geological Survey - Great Lakes Science Center, (USGS)
Tom MacDougall	- Ontario Ministry of Natural Resources and Forestry, (OMNRF)
Jim Markham	- New York Department of Environmental Conservation, (NYSDEC)
Greg Wright	- United States Fish and Wildlife Service, (USFWS)

Presented to:

Standing Technical Committee
Lake Erie Committee
Great Lakes Fishery Commission

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Forage Task Group Executive Summary

March 2020

Lake Erie Committee

REPRESENTING THE FISHERY MANAGEMENT AGENCIES OF LAKE ERIE AND LAKE ST. CLAIR

Introduction

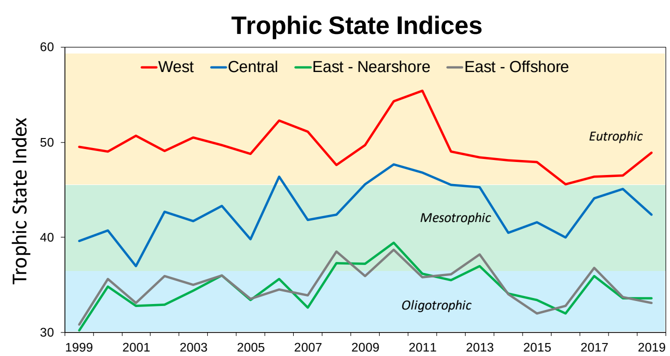
The Lake Erie Committee Forage Task Group (FTG) report addresses progress made on four charges:

1. Report on the results of the interagency lower trophic level monitoring program and status of trophic conditions as they relate to the Lake Erie Fish Community Goals and Objectives.
2. Describe the status and trends of forage fish in each basin of Lake Erie and evaluate alternate data sources and methods to enhance description of forage fish abundance.
3. Continue hydroacoustic assessment of the pelagic forage fish community in Lake Erie, incorporating new methods in survey design and analysis, while following the Great Lake Fishery Commission's Great Lakes Hydroacoustic Standard Operating Procedures where possible/feasible. Support the Standing Technical Committee (STC) review of hydroacoustics.
4. Act as a point of contact for any new/novel invasive aquatic species.

The complete report is available from the Great Lakes Fishery Commission's Lake Erie Committee Forage Task Group website (http://www.glfc.org/lake-erie-committee.php) or upon request from a Lake Erie Committee, STC, or FTG representative.

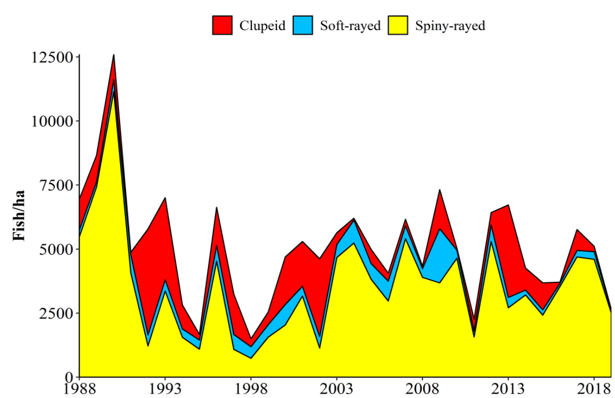
Interagency Lower Trophic Level Monitoring

The lower trophic level monitoring (LTLA) program has measured nine environmental variables at 18 stations around Lake Erie since 1999 to characterize ecosystem trends. The Trophic State Index, which is a combination of phosphorus levels, water transparency, and chlorophyll *a* concentration, indicate that the western basin is slightly above the targeted mesotrophic status, the central basin is within targeted mesotrophic status, and both the nearshore and offshore waters of the eastern basin are oligotrophic. Trends across Lake Erie in recent years indicate that overall productivity has slowly declined since 2010. Low hypolimnetic dissolved oxygen continues to be an issue in the central basin during the summer months.



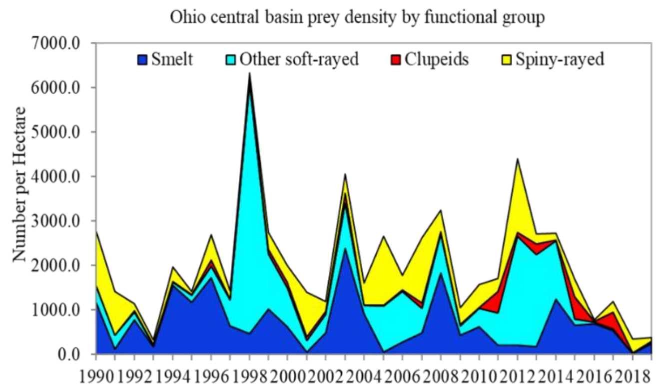
West Basin Status of Forage

In 2019, hypolimnetic dissolved oxygen levels were below the 2 mg/L threshold at twenty sites during the August trawling survey and, as a result, data from only 56 sites were used in 2019 (down from 71 in 2018). Total forage density averaged 2,633 fish per hectare across the western basin, which is a decline of 48% from 2018 and near half of the ten-year mean (5,029 fish/ha). Age-0 Walleye relative abundance in 2019 remained high and was the second greatest in the time series (225/ha). Young-of-the-year Yellow Perch (555/ha) declined 42% from 2018 but remained above the ten-year mean (400/ha). Young-of-the-year White Perch (1,573/ha) declined 50% from 2018 and is currently half the ten-year average (2,961/ha). Young-of-the-year White Bass (80/ha) was similar to 2018 and below the ten-year mean (130/ha). Young-of-the-year Gizzard Shad abundance (39/ha) was the lowest in the time series, well below the ten-year mean (914/ha). Densities of age-0 (0.4/ha) and age-1+ Emerald Shiners (0.1/ha) were also the lowest in the time series.



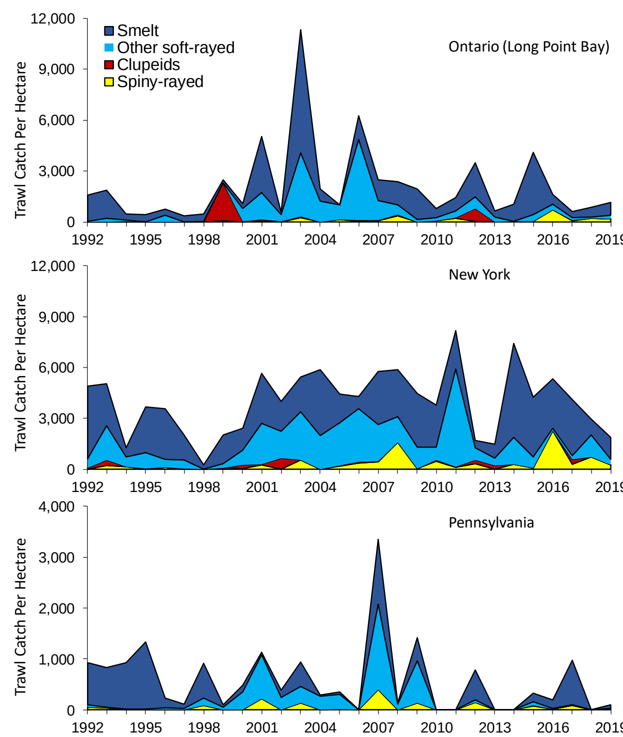
Central Basin Status of Forage

Forage abundance in Pennsylvania increased from 2018 and was primarily composed of Rainbow Smelt and spiny-rayed species. Forage densities in Ohio were similar to 2018, but species composition switched from spiny-rayed species to primarily Rainbow Smelt in 2019. Forage densities remain well below long-term means in both Pennsylvania and Ohio. Young-of-the-year Rainbow Smelt was the only species that increased from 2018 across the basin. In contrast, age-1+ Rainbow Smelt indices declined from 2018 and were some of the lowest indices in the time period. Round Goby increased in Ohio trawls but decreased in Pennsylvania. Gizzard Shad and Emerald Shiner indices were similar to 2018. Emerald Shiners have only been sampled occasionally since 2015. Since 2005, Yellow Perch cohorts in the central basin have tended to be strongest in the east relative to the west. In 2019, Yellow Perch age-0 indices increased in Pennsylvania but decreased in Ohio. Yearling-and-older Yellow Perch indices in the central basin decreased from 2018 and were well below long-term means. Ohio indices for age-1+ Yellow Perch have been generally below long-term means since 2013.



East Basin Status of Forage

Total forage fish abundance in 2019 increased in Ontario over 2018 but remained well below the long-term mean. Abundance decreased for the third consecutive year in New York. Total forage fish abundance was one of the lowest values recorded in Pennsylvania waters. Catches of age-0 Rainbow Smelt were below long-term means in all jurisdictions. Abundance of age 1+ Smelt and Emerald Shiners (all life stages) were very low in all jurisdictions. Catches of age-0 Yellow Perch were above average in Long Point Bay, but below average in both New York and Pennsylvania. Round Goby densities were generally consistent with long-term means. Catches of all other species were low.



Hydroacoustic Assessments

The Forage Task Group introduced fisheries hydroacoustic technology on Lake Erie to provide a more comprehensive assessment of pelagic forage fish species abundance and distribution. In 2019, the east basin survey was conducted from July 8-18, the central basin survey from July 8-12, and the west basin survey on July 8-11. East basin forage fish density was the lowest in the time series, with a mean of 180 fish the size of age-1+ Rainbow Smelt per hectare. Similarly, hydroacoustic densities and midwater trawl catch rates of age-1+ Rainbow Smelt in the central basin were some of the lowest in the time series. Emerald Shiner have been generally declining in the central basin since 2011 and have been in very low abundance in the survey since 2015. In the west basin, average forage fish densities were highest along the transect bordering the central basin (9687 fish/ha). Average western basin forage fish densities (8,335 fish/ha) were slightly higher than 2018 densities (6,435 fish/ha), but below the time series average (14,298 fish/ha).

Aquatic Invasive Species

No new invasive fish species were reported in Lake Erie or its' connected waterways in 2019. Grass Carp reporting is now handled by the Grass Carp Working Group, which includes representatives from all Lake Erie jurisdictions and participating agencies. We continue to track populations of Rudd in the Lake Erie watershed. Tench is an emerging species of concern given its rapid expansion in the St. Lawrence River and recent entrance into Lake Ontario.

Charges to the Forage Task Group 2019-2020

1. Report on the results of the interagency lower trophic level monitoring program and status of trophic conditions as they relate to the Lake Erie Fish Community Goals and Objectives.

2. Describe the status and trends of forage fish in each basin of Lake Erie and evaluate alternate data sources and methods to enhance description of forage fish abundance.

3. Continue hydroacoustic assessment of the pelagic forage fish community in Lake Erie, incorporating new methods in survey design and analysis, while following the Great Lake Fishery Commission's Great Lakes Hydroacoustic Standard Operating Procedures where possible/feasible. Support the Standing Technical Committee (STC) review of hydroacoustics.

4. Act as a point of contact for any new/novel invasive aquatic species.

Charge 1: Report on the results of the interagency lower trophic level monitoring program and status of trophic conditions as they relate to the Lake Erie Fish Community Goals and Objectives.

(J. Markham)

1.0 Background

In 1999, the Forage Task Group (FTG) initiated a Lower Trophic Level Assessment (LTLA) program within Lake Erie and Lake St. Clair (Figure 1.0.1). Nine key variables, as identified by a panel of lower trophic level experts, were measured to characterize ecosystem change. These variables included profiles of temperature, dissolved oxygen, light (PAR), water transparency (Secchi disc depth), nutrients (total phosphorus), chlorophyll *a*, phytoplankton, zooplankton, and benthos. The protocol called for each station to be visited every two weeks from May through September, totaling 12 sampling periods, with benthos collected on two dates, once in the spring and once in the fall. For this report, the last 21 years of data for summer surface temperature, summer bottom dissolved oxygen, chlorophyll *a* concentration, water transparency, total phosphorus, and zooplankton will be summarized. Data from all stations were included in the analysis unless stated otherwise.

The fish community objectives (FCO) for the lower trophic level ecosystem in Lake Erie are to maintain mesotrophic conditions that favor percids in the west, central and nearshore waters of the east basin, and oligotrophic conditions that favor salmonids in the offshore waters of the east basin (Ryan et al. 2003). Associated with these trophic classes are target ranges for total phosphorus, water transparency, and chlorophyll *a* (Table 1.0.1). For mesotrophic conditions, the total phosphorus range is 9-18 µg/L, summer (June-August) water transparency is 3-6 meters, and chlorophyll *a* concentrations between 2.5-5.0 µg/L (Leach et al. 1977). For the offshore waters of the east basin, the target for total phosphorus are < 9 µg/L, summer water transparency of > 6 m, and chlorophyll *a* concentrations of < 2.5 µg/L.

A trophic state index (TSI; Carlson 1977) was used to produce a metric which merges three independent variables to report a single broader measure of trophic conditions. This index uses algal biomass as the basis for trophic state classification, which is independently estimated using measures of chlorophyll *a*, water transparency, and total phosphorus. Each independent measure is combined and the average of the three indices reflects a trophic state value for that site and sampling event. The median value of the combined daily indices is used to determine an annual index for each basin. Because the number generated is only a relative measure of the trophic conditions and does not define trophic status, this index was calibrated to accepted Lake Erie ranges for values of total phosphorus, chlorophyll *a*, and transparency (from Leach et al. 1977) that have long been used to assess trophic conditions. In these terms, oligotrophic was determined to have a TSI < 36.5, mesotrophic between 36.5 and 45.5, eutrophic between 45.5 and 59.2, and hyper-eutrophic > 59.2.

1.1 Mean Summer Surface Water Temperature

Summer surface water temperature represents the temperature of water at a depth of 0-1 meters for offshore stations only. This index should provide a good measure of relative system production and growth rate potential for fishes, assuming prey resources are not limiting. Mean summer surface temperatures across all years are warmest in the west basin (mean = 23.5 °C), becoming progressively cooler in the central (mean = 22.0 °C) and east basins (mean = 20.6 °C; Figure 1.1.1). In 2019, the mean summer surface water temperature was near average in the west basin (23.3 °C), but well below average in the central (18.2°C) and east basins (18.9 °C). In fact, the mean summer surface temperature in 2019 was the lowest in the time series for the central basin, and the second lowest in the east basin. A slight increasing trend in summer surface water temperature is evident in the west basin, whereas there is a slightly decreasing trend in the central basin; no trend is evident in the east basin. The low temperatures in 2019 in the central and east basins heavily influenced their temperature trends.

1.2 Hypolimnetic Dissolved Oxygen

Dissolved oxygen (DO) levels less than 2.0 mg/L are deemed stressful to fish and other aquatic biota (Craig 2012; Eby and Crowder 2002). Low DO can occur when the water column becomes stratified, which can begin in early June and continue through September in the central and east basins. In the west basin, shallow depths allow wind mixing to penetrate to the bottom, generally preventing thermal stratification. Consequently, there are only a few summer observations that detect low bottom DO concentrations in the time series (Figure 1.2.1). In 2019, there was one observation from the west basin stations of DO below the 2.0 mg/L threshold (Station 6 on 7/27/19 – 1.6 mg/L) and two occasions of DO just above the 2.0 mg/L threshold (Station 3: 7/18/19 – 3.2 mg/L; Station 6: 7/31/19 – 2.7 mg/L).

Low DO is more of an issue in the central basin, where it happens almost annually at the offshore stations (8, 10, 11 and 13) and occasionally at inshore stations. Dissolved oxygen of less than 2.0 mg/L has been observed as early as mid-June and can persist until late September when fall turnover remixes the water column. In 2019, bottom DO was below the 2.0 mg/L threshold in the central basin at two stations on five occasions (Station 10: 8/16/10 – 1.4 mg/L; Station 8: 6/10/19 – 0.9 mg/L; 7/18/19 – 0.1 mg/L; 8/1/19 – 0.4 mg/L; 8/27/19 – 0.6 mg/L; Figure 1.2.1).

DO is rarely limiting in the east basin due to greater water depths, a large hypolimnion and cooler water temperatures. The only occasion when DO was below the 2.0 mg/L threshold was on 14 July and 13 August, 2010 (Figure 1.2.1). In 2019, all measures of DO concentration exceed 7.0 mg/L in the east basin.

1.3 Chlorophyll *a*

Chlorophyll *a* concentrations indicate biomass of the phytoplankton resource, ultimately representing production at the lowest trophic level. In the west basin, mean chlorophyll *a* concentrations have mainly been above targeted levels in the 21 year time series, fitting into eutrophic status rather than the targeted mesotrophic status (Figure 1.3.1). Annual variability is also the highest in the west basin. In 2019, the mean chlorophyll *a* concentration was 10.2 µg/L in the west basin, which was the highest measure since 2015 and well above the targeted mesotrophic range. In the central basin, chlorophyll *a* concentrations have been less variable and within the targeted mesotrophic range for the entire time series; a trend that continued in 2019 (4.4 µg/L; Figure 1.3.1). In the east basin, chlorophyll *a* concentrations in the nearshore waters have been below the targeted mesotrophic level for the entire time series (Figure 1.3.1). This may be due to high levels of grazing by dreissenids (Nicholls and Hopkins 1993) in the nearshore east basin waters where biomass of quagga mussels (*Dreissena bugensis*) remains high (Patterson et al. 2005). Conversely, chlorophyll *a* levels in the offshore waters of the east basin remain in, or slightly above, the targeted oligotrophic range. In 2019, the mean chlorophyll *a* concentrations were 1.6 µg/L in the nearshore waters of the east basin and 2.1 µg/L in the offshore waters, both of which were oligotrophic. Chlorophyll *a* concentrations are most stable in the east basin.

1.4 Total Phosphorus

Total phosphorus levels in the west basin have exceeded FCO targets since the beginning of the LTLA monitoring program, and in some years has been in the hyper-eutrophic range (Figure 1.4.1). In 2019, total phosphorus concentrations in the west basin increased for the third consecutive year to 40.0 µg/L, remaining well above targets. In the central basin, total phosphorus levels had exceeded FCO targets from 2006 through 2013, were borderline mesotrophic/eutrophic in 2014 and 2015, and then increased in 2016 and 2017 (Figure 1.4.1). Total phosphorus measures in the central basin in 2019 were 19.5 µg/L, which was the second consecutive decline and near the mesotrophic target. In the nearshore waters of the east basin, total phosphorus levels have remained stable and within or near the targeted mesotrophic range for the entire time series (Figure 1.4.1). A gradual increasing trend was evident from 2006 through 2010, but a declining trend has been evident since 2010. Total phosphorus levels in the offshore waters of the east basin show a similar trend to nearshore waters, whereby total phosphorus rose above the targeted oligotrophic range from 2008 through 2013 and declined in more recent years. In 2019, mean total phosphorus concentrations in the east basin remain similar to the previous year in both the nearshore (8.2 µg/L) and offshore (8.0 µg/L) waters, which puts them below the targeted mesotrophic range in the nearshore waters and within the targeted oligotrophic range in the offshore waters.

1.5 Water Transparency

Similar to other fish community ecosystem targets (i.e., chlorophyll *a*, total phosphorus), water transparency in the west basin has been in the eutrophic range for the entire time series (Figure 1.5.1). Mean summer transparency in the west basin was 2.8 m in 2018, which represents an increase from 2018 measures. In contrast, water transparency in the central basin has remained within the targeted mesotrophic range for the entire series, with the exception of 2015 (2.9 m), which was slightly below the mesotrophic target range (Figure 1.5.1). In 2019, water transparency increased to 4.7 m and was well within the targeted mesotrophic range. In the nearshore waters of the east basin, water transparency was in the oligotrophic range from 1999-2006, shifted into the mesotrophic range from 2007-2015, and has hovered around the cusp of the mesotrophic/oligotrophic range since 2016 (Figure 1.5.1). In 2019, water transparency decreased in the nearshore waters of the east basin to 5.9 m, which is within the targeted mesotrophic range. In the offshore waters of the east basin, water transparency was within the oligotrophic target from 1999 through 2007, decreased into the mesotrophic range in five of the next six years, and then increased thereafter. In 2019, mean summer transparency decreased to 6.6 m in the offshore waters but remained within the targeted oligotrophic range.

1.6 Trophic State Index (TSI) and Ecosystem Targets

A box and whisker plot was used to describe the trophic state index (TSI) for each of the basins in Lake Erie (Figure 1.6.1). Median TSI values indicate that the west basin remained in a eutrophic status from the beginning of the time series until 2015. A eutrophic state is considered to be more favorable for a centrarchid (Smallmouth Bass, Bluegill) fish community (Ryder and Kerr 1978). In recent years, overall measures of productivity have declined and are near or within the targeted mesotrophic status, which is more favorable for percid (Walleye and Yellow Perch) production (Ryder and Kerr 1978). In the central basin, median TSI values have generally remained within the targeted mesotrophic range for the entire time series. The nearshore waters of the east basin have had median TSI values within the oligotrophic range for the entire time series, with some individual measurements in the mesotrophic range. Similar trends are apparent in the offshore waters of the east basin. The TSI values for 2019 indicate borderline meso/eutrophic status in the west basin (48.9), mesotrophic status in the central basin (42.4), and oligotrophic status in both the nearshore (33.6) and offshore (33.1) waters of the eastern basin (Table 1.6.1). Trends in trophic status measures indicate that Lake Erie has decreased in productivity over the past decade, but generally remains in a favorable condition for percid production.

1.7 Zooplankton Biomass

Average zooplankton biomass varies among basins and years. In the west basin, the 2019 average biomass was 360.3 mg/m^3, which was the highest value in the time series and well above the long term average of 114.8 mg/m^3 (Figure 1.7.1). The increase in biomass in 2019 was primarily due to greater numbers of cladocerans, mainly large-bodied *Daphnia* spp.; declines were observed for calanoid copepods compared to recent years. Cladocerans typically provide the bulk of the biomass of zooplankton in the west basin, although increases in both calanoid and cyclopoid copepods had been observed in recent years. In the central basin, the 2019 average zooplankton biomass was 169.1 mg/m^3, which was above the average time series biomass (141.6 mg/m^3). This represented a slight increase over 2018; zooplankton biomass in the central basin has been generally stable over the past six years (Figure 1.7.1). Calanoid copepods have typically been higher in biomass in the central basin compared to the west basin, but copepod biomass has been conspicuously low in the central basin for the past six years. In the east basin, overall zooplankton biomass is traditionally lower compared to the central and west basins (Figure 1.7.1). Cladocerans and calanoid copepods are equally important in the zooplankton community of the east basin. Zooplankton biomass in the east basin increased over recent years in 2019 (73.3 mg.m^3) and was above the time series average (59.5 mg/L). The increase in biomass in 2019 was primarily due to greater numbers of large-bodied *Daphnia* spp. and nauplii.

Looking at larger trends, there appeared to be a gradient of high zooplankton biomass in the west and lower biomass in the east from 2000 to 2007. From 2009 through 2013, zooplankton biomass increased in the central and east basins, but shifted back to the west basin in 2015 with declines observed in the central and east basins. Cladocerans are typically more dominant in the west basin zooplankton community and decline to the east, while calanoid and cyclopoid copepods tend to be higher in biomass in the central and east basins.

Table 1.0.1: Ranges of lower trophic indicators for each trophic class and trophic state index with the associated fish community (Leach et al. 1977; Ryder and Kerr 1978; Carlson 1977).

Trophic Status	Phosphorus (µg/L)	Chlorophyll a (µg/L)	Transparency (m)	Trophic State Index (TSI)	Harmonic Fish Community
Oligotrophic	<9	<2.5	>6	<36.5	Salmonids
Mesotrophic	9 - 18	2.5 - 5.0	3 - 6	36.5 – 45.5	Percids
Eutrophic	18 - 50	5.0 - 15	1 - 3	45.5 – 59.2	Centrarchids
Hyper-eutrophic	>50	>15	<1	>59.2	Cyprinids

Table 1.6.1: Trophic state index and current trophic status, by basin, from Lake Erie in 2019. The east basin is separated into nearshore and offshore.

Trophic Status	Trophic State Index (TSI)	Harmonic Fish Community
Oligotrophic	<36.5	Salmonids
Mesotrophic	36.5 – 45.5	Percids
Eutrophic	45.5 – 59.2	Centrarchids
Hyper-eutrophic	>59.2	Cyprinids

	2019 TSI	2019 Trophic Status
West	48.9	Eutrophic
Central	42.4	Mesotrophic
East - Nearshore	33.6	Oligotrophic
East - Offshore	33.1	Oligotrophic

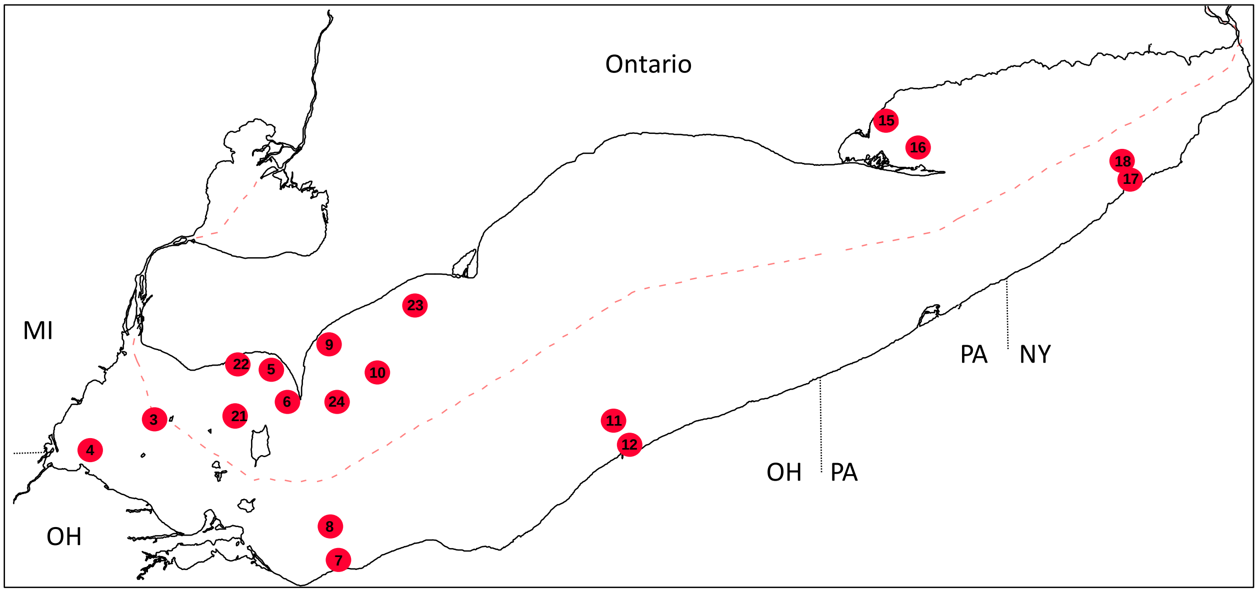


Figure 1.0.1: Lower trophic level sampling stations in Lake Erie sampled in 2019.

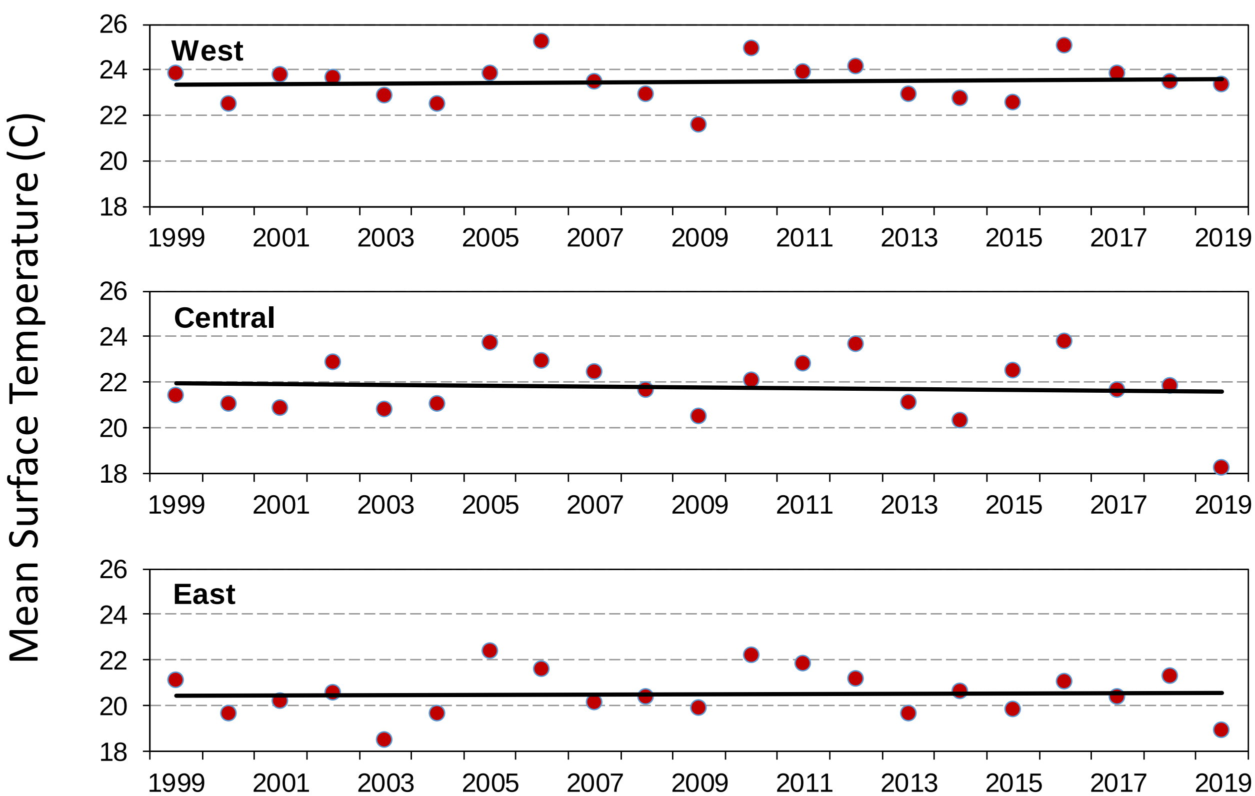


Figure 1.1.1: Mean summer (June-August) surface water temperature (°C) at offshore stations, weighted by month, by basin in Lake Erie, 1999-2019. Solid black lines represent time series trends.

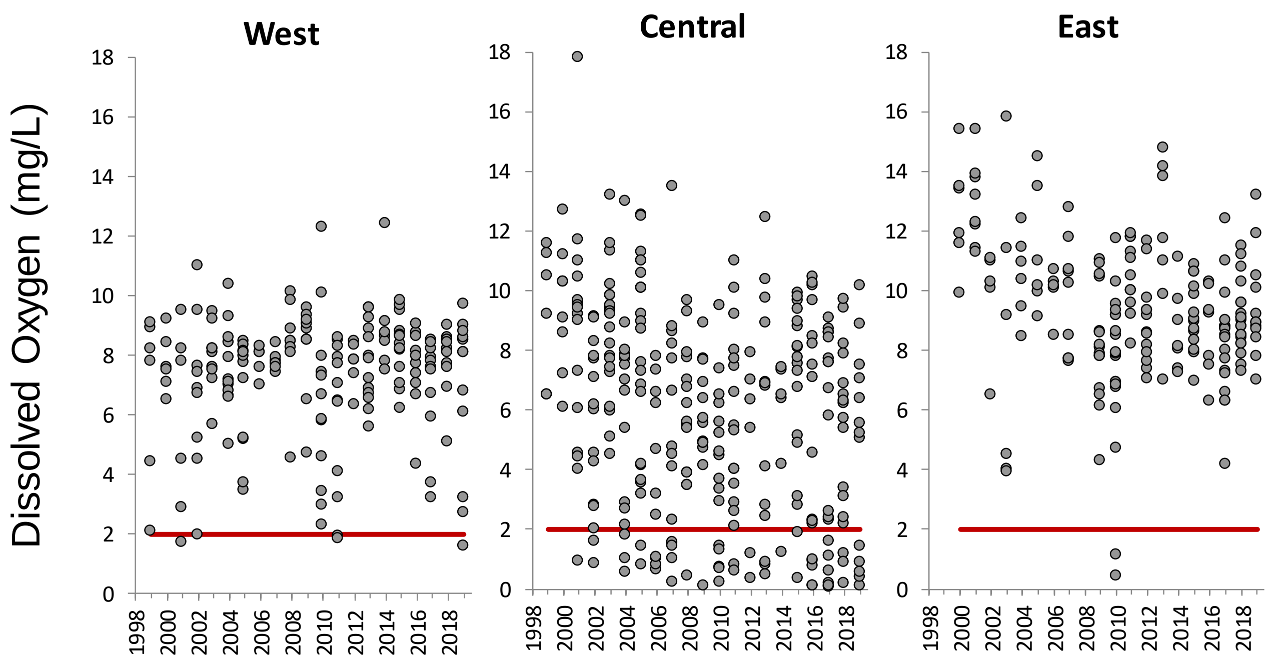


Figure 1.2.1: Summer (June-August) bottom dissolved oxygen (mg/L) concentrations for offshore sites by basin in Lake Erie, 1999-2019. The red horizontal line represents 2 mg/L, a level below which oxygen becomes limiting to the distribution of many temperate freshwater fishes.

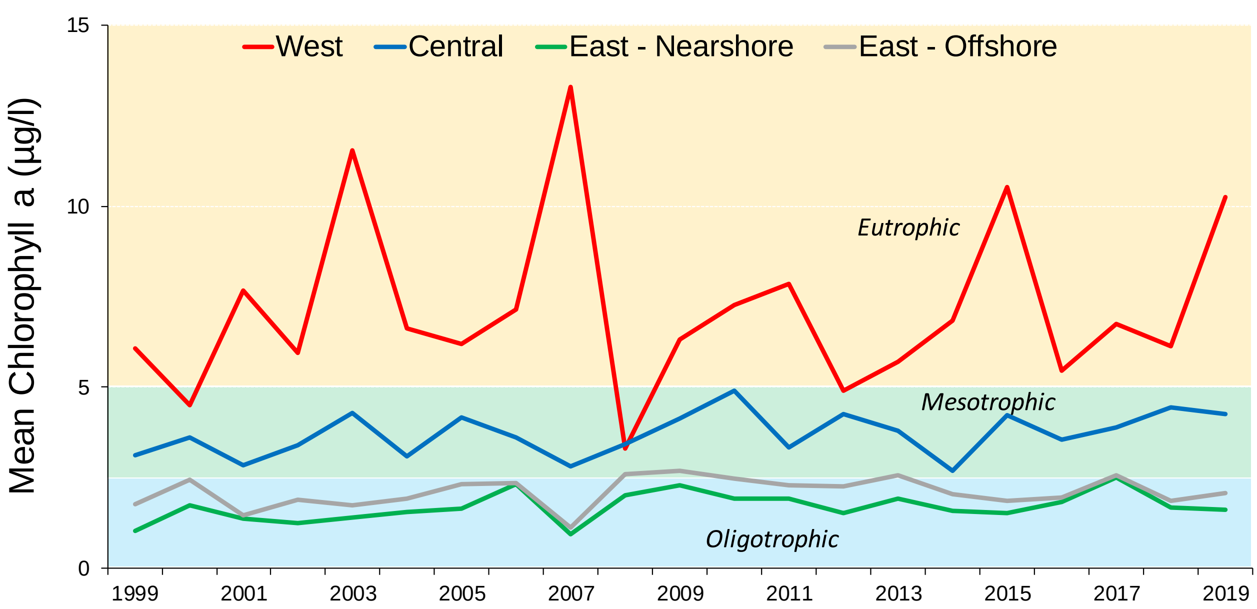


Figure 1.3.1: Mean chlorophyll *a* concentration (µg/L), weighted by month, by basin in Lake Erie, 1999-2019. The east basin is separated into nearshore and offshore. Shaded areas represent trophic class ranges.

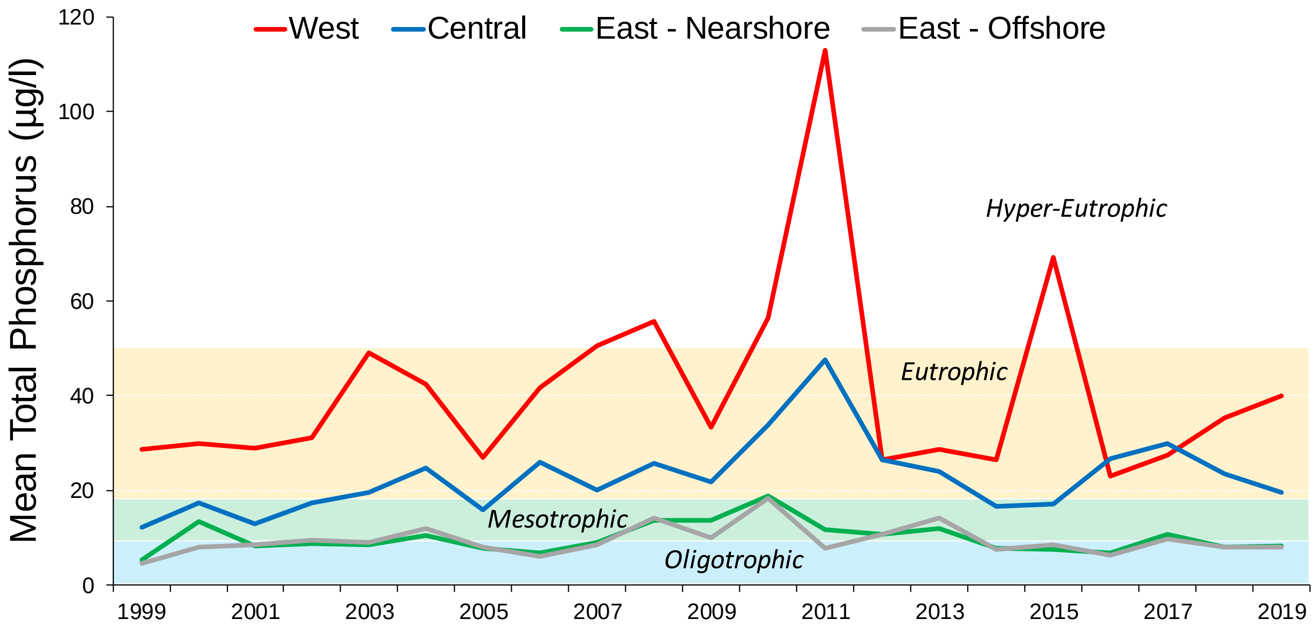


Figure 1.4.1: Mean total phosphorus (µg/L), weighted by month, for offshore sites by basin in Lake Erie, 1999-2019. The east basin is separated into nearshore and offshore. Shaded areas represent the trophic class ranges.

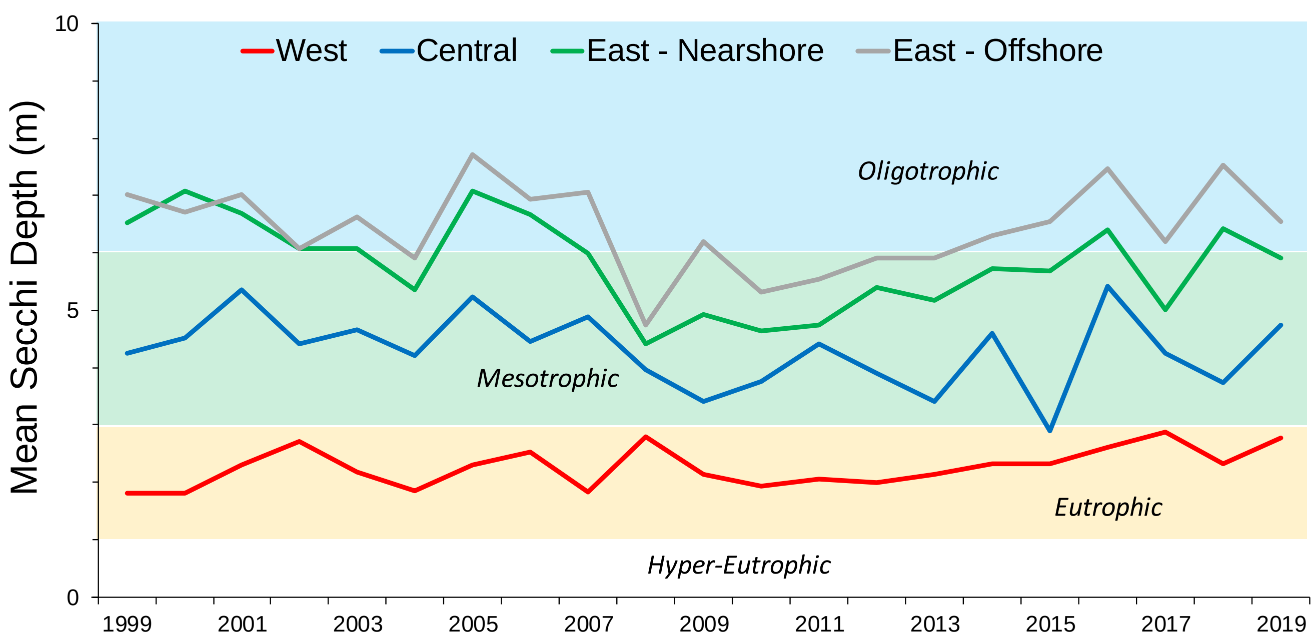
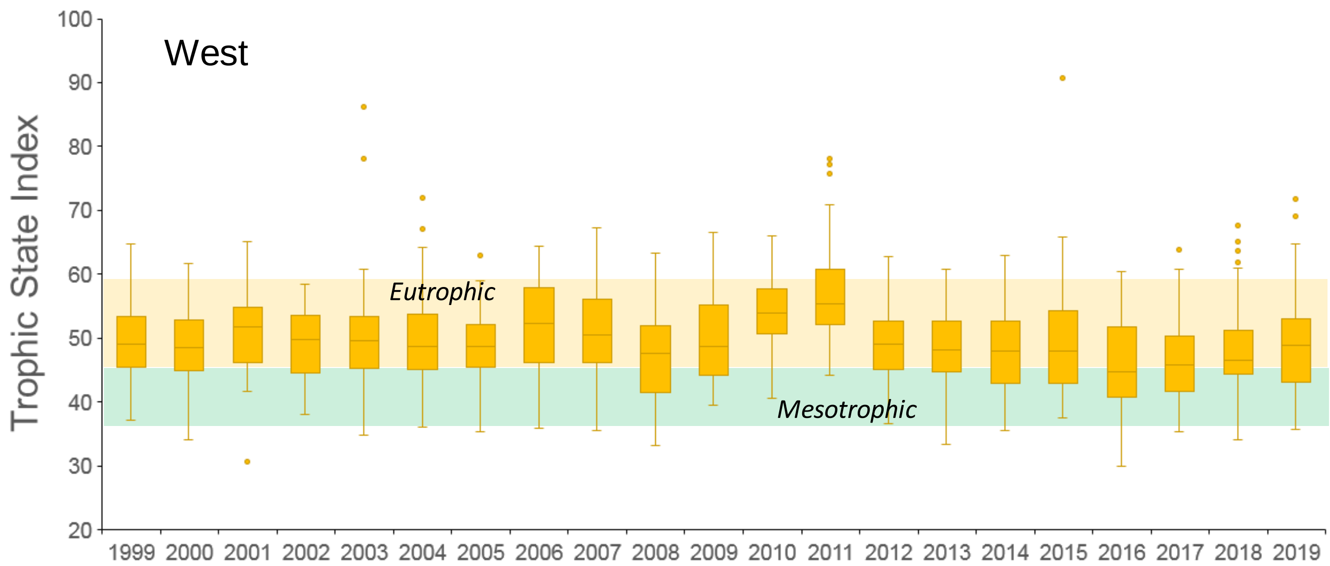


Figure 1.5.1: Mean summer (June-August) Secchi depth (m), weighted by month, by basin in Lake Erie, 1999-2019. The east basin is separated into inshore and offshore. Yellow shaded areas represent the targeted trophic class range.



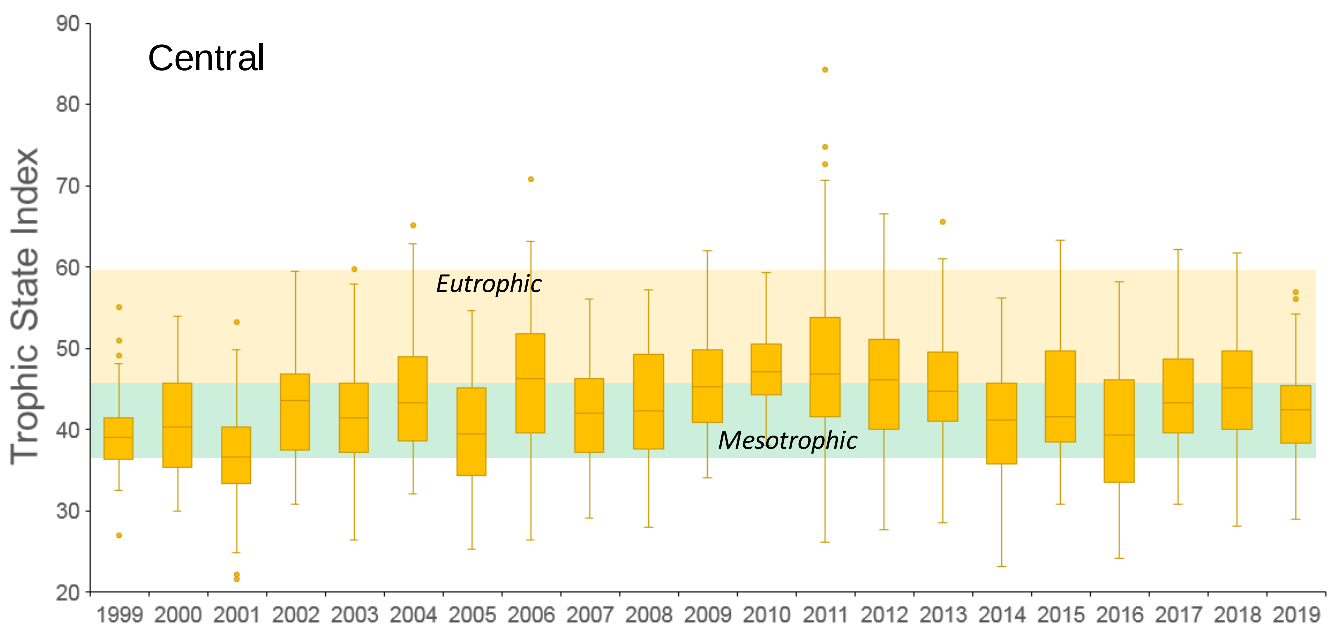
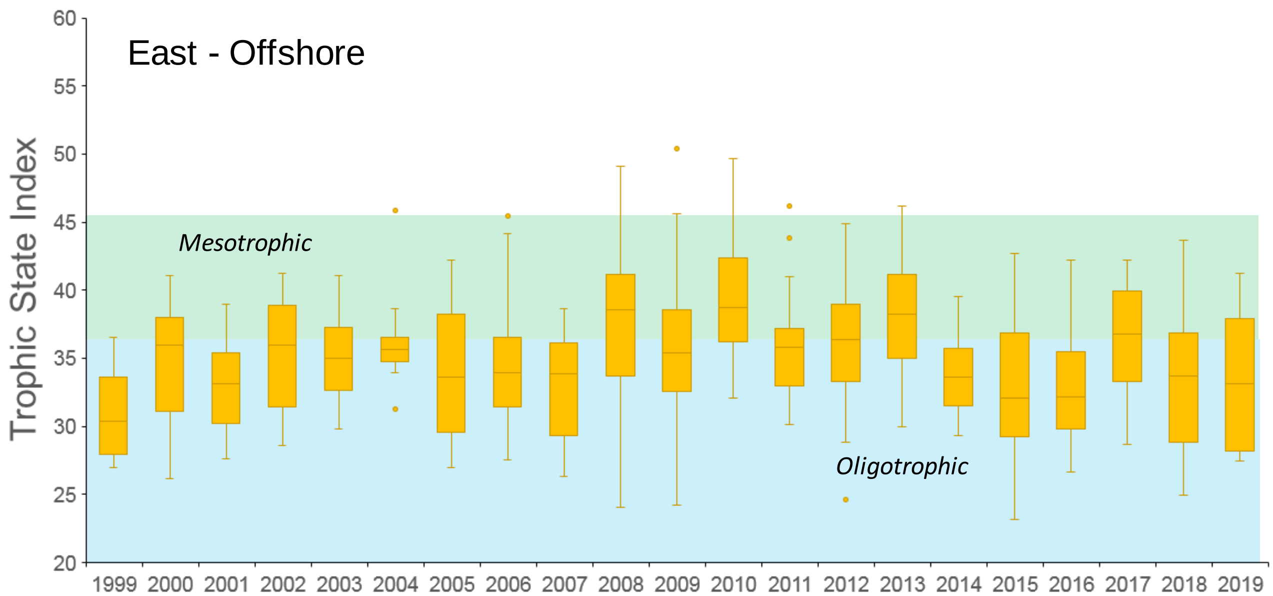


Figure 1.6.1: Box and whisker plot of trophic state indices (TSI) by basin in Lake Erie, 1999-2019. The east basin is separated into nearshore and offshore. Shaded areas represent trophic class ranges. Boxes indicate 25th and 75th quartiles of the values with the median value as the horizontal line. Vertical lines show the range of values with individual points representing outliers.



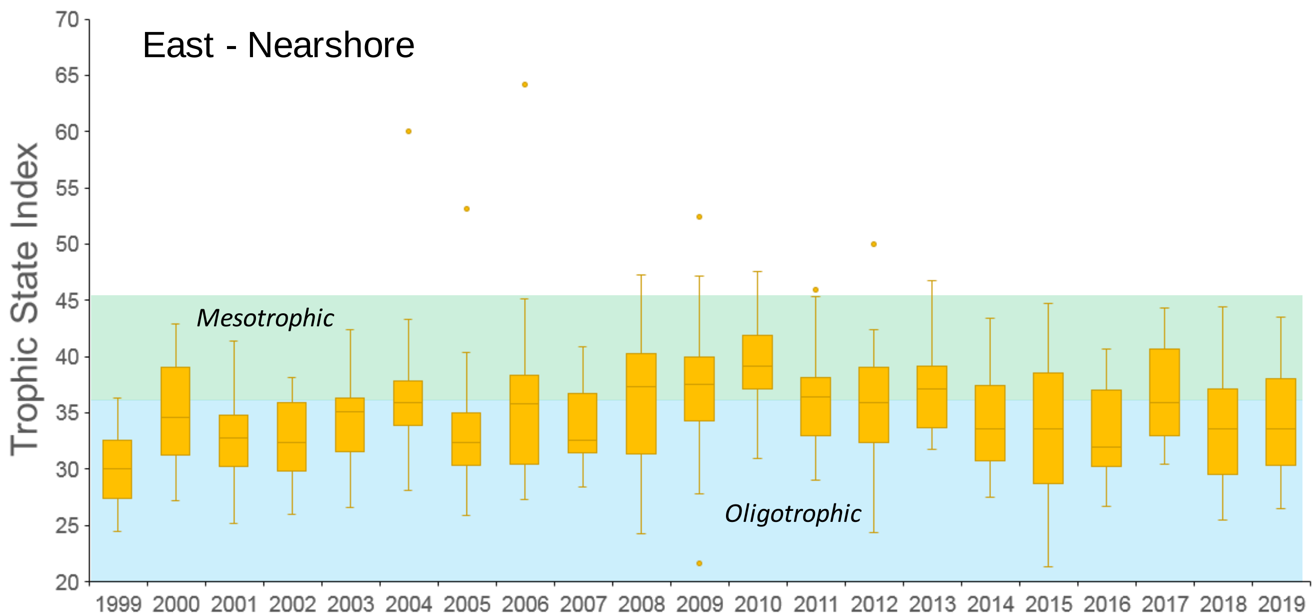


Figure 1.6.1: (Continued) Box and whisker plot of trophic state indices (TSI) by basin in Lake Erie, 1999-2019. The east basin is separated into nearshore and offshore. Shaded areas represent trophic class ranges. Boxes indicate 25th and 75th quartiles of the values with the median value as the horizontal line. Vertical lines show the range of values with individual points representing outliers.

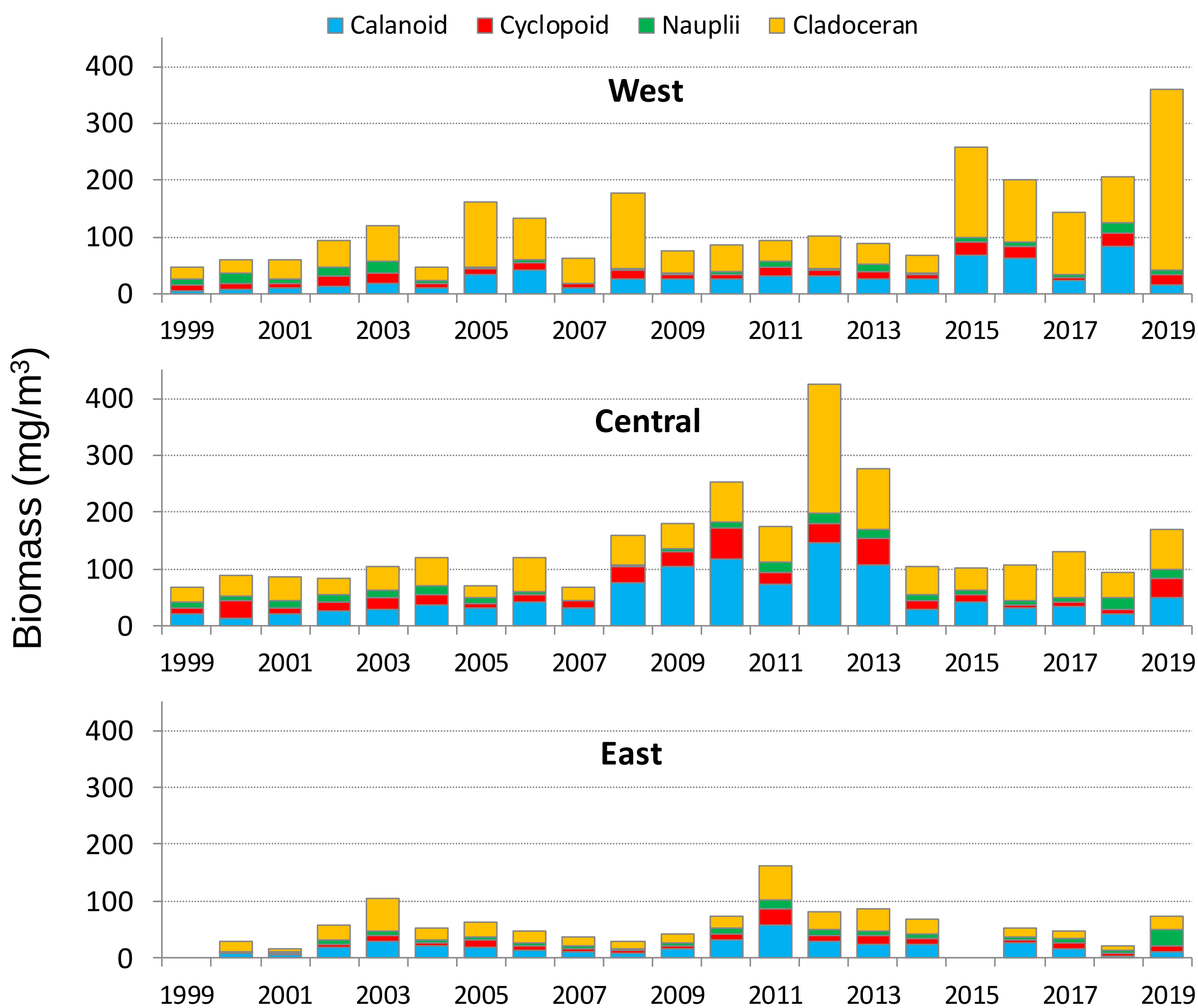


Figure 1.7.1: Average zooplankton biomass (mg/m^3) by major taxonomic group by basin, 1999-2019. There is no data for 1999 and 2015 in the east basin. Data excludes rotifers and veligers. Harpacticoid zooplankton comprise a miniscule biomass for most years and are not included in the graph.

Charge 2: Describe the status and trends of forage fish in each basin of Lake Erie and evaluate alternate data sources and methods to enhance description of forage fish abundance.

2.1 Synopsis of 2019 Forage Status and Trends

Eastern Basin

- Total forage fish abundance in 2019 increased in Ontario over 2018 but remained well below the long-term mean. Abundance decreased for the third consecutive year in New York. Total forage fish abundance was among the lowest values recorded in Pennsylvania waters.
- Catches of age-0 Rainbow Smelt were below long-term means in all jurisdictions.
- Catches of age-1+ Rainbow Smelt were very low all jurisdictions.
- Emerald Shiner catches of both age-0 and age-1+ were low in all jurisdictions.
- Round Goby densities were generally consistent with long-term means in all jurisdictions.
- Catches of all other species were low.

Central Basin

- Overall forage abundance increased in Pennsylvania and was similar to 2018 in Ohio.
- In 2019, all forage indices were below long-term means.
- Young-of-the-year Rainbow Smelt and spiny-rayed species were the primary forage groups in the central basin.
- Yellow Perch age-0 indices increased in Pennsylvania but decreased in Ohio.
- Yearling-and-older Rainbow Smelt indices declined from 2018 and were at some of the lowest values in the time period.
- Round Goby increased in both Ohio indices, but decreased in Pennsylvania.
- Gizzard Shad indices remained similar to 2018.
- Emerald Shiners have only been sampled occasionally since 2015.

West Basin

- Forage abundance in 2019 declined ~50% from 2018 and approached half of the ten-year mean.
- Forage composition in 2019 was 60% Age-0 White Perch, 21% Age-0 Yellow Perch, 9% Age-0 Walleye, and 10% other species.
- Young-of-the-year White Perch density declined 50% from 2018, driving overall forage abundance down.
- Young-of-the-year Yellow Perch recruitment declined relative to last year but was 39% above the ten-year mean.
- Young-of-the-year Walleye recruitment declined 12% from 2018's historic year class but was still the second largest year class in the time series.

- Forage biomass decreased 47% from 2018 and was 34% below the ten-year mean
- White Bass recruitment was similar to 2018 and approximately 60% of the ten-year mean.
- Age-0 Gizzard Shad abundance was only 4% of the ten-year mean.
- Young-of-the-year and age-1+ Emerald Shiner indices were near zero in 2019, the lowest in the time series.
- Round Goby abundance nearly doubled from 2018.
- Adult Silver Chub abundance was 10.3 fish/ha, the largest since 2003.

2.2 Eastern Basin Status of Forage (A. Bonsall, J. Markham and M. Hosack)

Forage fish abundance and distribution is determined primarily from long-term bottom trawl assessments conducted by each agency in the basin (also see East Basin Hydroacoustic Survey, Section 3.1). In 2019, a total of 34 trawl tows were sampled across New York waters, 110 trawl tows in nearshore and offshore Long Point Bay (Ontario), and 12 in the eastern basin waters of Pennsylvania (Figure 2.2.1).

In 2019, overall forage fish densities decreased for the third consecutive year in New York and were well below the time series averages in both Ontario and Pennsylvania (Figure 2.2.2). Rainbow Smelt is typically the most abundant forage species in most years and jurisdictions (Figure 2.2.2). In 2019, Rainbow Smelt catches were primarily composed of age-0 individuals; very low densities of age-1+ Rainbow Smelt were caught in any jurisdiction (Table 2.2.1). Emerald Shiner catches were again low in 2019 for all surveys (Table 2.2.1). Round Goby, an important species in the eastern basin forage fish community since it appeared in the late 1990s, peaked in the mid-2000s and have since generally remained at a lower but stable abundance in all jurisdictions (Table 2.2.1). Catches of all other species were low in 2019 (Table 2.2.1).

2.3 Central Basin Status of Forage (J. Deller and M. Hosack)

Routine bottom trawl surveys to assess age-0 percid and forage fish abundance and distributions within the central basin began in Pennsylvania in 1982 and in Ohio in 1990. Trawl locations in Pennsylvania range from 13 to 24 m in depth and Ohio trawl locations range from 5 to >20 m in depth (Figure 2.3.1). Ohio West covers the area from Lorain to Fairport Harbor. Ohio East covers the area from Fairport Harbor to the Pennsylvania state line. The Pennsylvania survey covers the area from the Pennsylvania state line to Erie. In 2019, 59 trawl tows were completed in the central basin with 23 in Pennsylvania and 36 in Ohio. Currently, there are no annual trawl surveys in Ontario. To address this gap, OMNRF and USGS are collaborating to develop a new survey. Preliminary trawls were conducted in 2018. Future results from the OMNRF survey will be included in the Forage Task Group Report.

Forage abundance in Pennsylvania increased from 2018 and was primarily composed of Rainbow Smelt and spiny-rayed species (Figure 2.3.2). Forage densities in Ohio were similar to 2018, but species composition switched from spiny-rayed species to primarily Rainbow Smelt in 2019. Forage densities remain well below long-term means in both Pennsylvania and Ohio.

Relative abundance of Rainbow Smelt, Round Goby, Gizzard Shad and Emerald Shiner, which are the primary forage species, showed mixed results in 2019 (Tables 2.3.1 and 2.3.2). Young-of-the-year Rainbow Smelt was the only species to show an increase relative to 2018 across the basin. In contrast, age-1+ Rainbow Smelt relative abundance declined from 2018 and was among the lowest values in the time series. Round Goby increased in both Ohio surveys but decreased in Pennsylvania. Gizzard Shad and Emerald Shiner relative abundance were similar to

2018. Emerald Shiners have only been sampled occasionally since 2015. All Rainbow Smelt, Round Goby, Gizzard Shad and Emerald Shiner indices were below long-term means in Pennsylvania and Ohio.

Since 2005, Yellow Perch cohorts in the central basin have tended to be strongest in the east relative to the west. In 2019, Yellow Perch age-0 relative abundance increased in Pennsylvania but decreased in Ohio. All Yellow Perch age-0 indices were well below long-term means (Table 2.3.1). Yearling-and-older indices in the central basin decreased from 2018 and were well below long-term means (Table 2.3.2). Both Ohio indices have generally been below long-term means since 2013.

Trends in White Perch age-0 indices across the central basin were also mixed. Indices in Pennsylvania increased from 2018, while Ohio indices decreased. Yearling-and-older indices increased from 2018 across the basin. Similar to other forage species, White Perch indices are below long-term means.

2.4 Western Basin Status of Forage

2.4.1 Interagency Trawling (Z. Slagle and E. Weimer)

Interagency trawling has been conducted in Ontario and Ohio waters of the western basin of Lake Erie in August of each year since 1987, though missing effort data from 1987 has resulted in the use of data since 1988. The interagency trawling program was developed to measure basin-wide recruitment of percids but has been expanded to provide basin-wide community abundance indices. In 1992, the Interagency Index Trawl Group (ITG) recommended that the Forage Task Group review its interagency trawling program and develop standardized methods for measuring and reporting basin-wide community indices. Historically, indices from bottom trawls had been reported as relative abundances, precluding the pooling of data among agencies. In 1992, in response to the ITG recommendation, the FTG began the standardization and calibration of trawling procedures among agencies so that the indices could be combined and quantitatively analyzed across jurisdictional boundaries. SCANMAR was employed by most Lake Erie agencies in 1992, by OMNRF and ODNR in 1995, and by ODNR alone in 1997 to calculate actual fishing dimensions of the bottom trawls. In the western basin, net dimensions from the 1995 SCANMAR exercise are used for the OMNRF vessel, while the 1997 results are applied to the ODNR vessel. In 2002, ODNR began interagency trawling with the vessel R/V *Explorer II* and SCANMAR was again employed to estimate the net dimensions in 2003. In 2003, a trawl comparison exercise among all western basin research vessels was conducted, and fishing power correction factors (Table 2.4.1) have been applied to data from the vessels administering the western basin Interagency Trawling Program ever since (Tyson et al. 2006). Presently, the FTG estimates basin-wide abundance of forage fish in the western basin using information from SCANMAR trials, trawling effort distance, and catches from the August interagency trawling program. Species-specific abundance estimates (number per hectare) are combined with length-weight data to generate a species-specific biomass estimate for each tow. Arithmetic mean volumetric estimates of abundance and biomass are extrapolated by depth strata (0-6m, >6m) to the entire western basin to obtain a fishing-power-correction-adjusted absolute estimate of forage fish abundance and biomass for each species. For reporting purposes, species have been pooled into three functional groups: clupeids (age-0 Gizzard Shad and Alewife), soft-rayed fish (Rainbow Smelt, Emerald Shiner, Spottail Shiner, other cyprinids, Silver Chub, Trout-Perch, and Round Goby), and spiny-rayed fish (age-0 White Perch, White Bass, Yellow Perch, Walleye and Freshwater Drum).

Hypoxic conditions have been observed during previous years of interagency bottom trawl assessment in the west basin. Due to concerns about the potential effects of hypoxia on the distribution of juvenile percids and other species, representatives from task groups, the Standing Technical Committee, researchers from the Quantitative Fisheries Center at Michigan State University and Ohio State University (OSU) developed an interim policy for the assignment of bottom trawl status. Informed by literature (Eby and Crowder 2002; Craig and Crowder 2005) and field study (ODNR /OSU/USGS) concerning fish avoidance of hypoxic waters, an interim policy was agreed upon whereby bottom trawls that occurred in waters with dissolved oxygen less than or equal to 2 mg per liter would be excluded from analyses. The policy has been applied retroactively from 2009. Currently, there is no consensus among task groups on the best way to handle this sort of variability in the estimation of year-class strength in Lake Erie. In part, this situation is hampered by a lack of understanding of how fish distribution changes in response to low dissolved oxygen. This interim policy will be revisited in the future following an improved understanding of the relationship between dissolved oxygen and the distribution of fish species and life stages in Lake Erie (Kraus et al. 2015).

2019 Results

In 2019, hypolimnetic dissolved oxygen levels were below the 2 mg/L threshold at twenty sites during the August trawling survey; all hypoxic sites were located either west of Point Pelee or on the eastern edge of the West Basin bordering the Central Basin. In total, data from only 56 sites were used in 2019, down from 71 in 2018 (Figure 2.4.1).

Total forage abundance in 2019 declined 48% from last year and was near half of the ten-year mean (Figure 2.4.2; Table 2.4.2). Spiny-rayed abundance declined 46% from 2018, while soft-rayed species declined 66% from 2018 – the lowest abundance in the time series. Clupeid abundance also declined to the minimum in the time series (since 1988). Total forage density averaged 2,633 fish/ha across the western basin, which represents a decline of 48% from 2018 and near half of the ten-year mean (5,029 fish/ha). Clupeid density was only 39 fish/ha (ten-year mean 914 fish/ha), soft-rayed fish density was 99 fish/ha (mean 478 fish/ha), and spiny-rayed fish density was 2,495 fish/ha (mean 3,637 fish/ha). Relative abundance of the dominant species includes: age-0 White Perch (60%), age-0 Yellow Perch (21%), age-0 Walleye (9%), followed by age-0 White Bass (3%) and age-0 Freshwater Drum (2%; other fishes = 5%). Total forage biomass in 2019 decreased by nearly half (47%) compared to 2018 (Figure 2.4.3). Relative biomass of clupeid, soft-rayed, and spiny-rayed species in 2019 was 3%, 4%, and 94%, respectively, and differed from their respective ten-year averages by 24%, 5%, and 72%.

Recruitment of individual species remains highly variable in the western basin (Table 2.4.3). Age-0 Walleye relative abundance in 2019 was the second greatest in the time series (225/ha), which is down 12% from 2018's largest year class on record but well above even the 2003 year class (183/ha; Figure 2.4.4). Young-of-the-year Yellow Perch (555/ha; Figure 2.4.4) declined 42% from 2018 and remained above the ten-year mean (400/ha) for the second year in a row. Young-of-the-year White Perch (1,573/ha) declined 50% from 2018, half the ten-year average (2,961/ha; Figure 2.4.5). Young-of-the-year White Bass (80/ha) was similar to 2018 and below the ten-year mean (130/ha). Densities of age-0 Rainbow Smelt (11/ha) and age-1+ Rainbow Smelt (0/ha) were minimal. Young-of-the-year Gizzard Shad abundance (39/ha) was the lowest in the time series (914/ha) and continued a trend of high annual variation (Figure 2.4.5). Densities of age-0 (0.4/ha) and age-1+ Emerald Shiners (0.1/ha) were also the lowest in the time series and well under their ten-year means (56/ha and 62/ha, respectively; Figure 2.4.6). Age-1+ Silver Chub relative abundance (10/ha) was the greatest since 2003, well above the ten-year mean (1.2/ha). Age-1+ Spottail Shiner 2019 density (2.4/ha) declined to just under the ten-year mean (2.8/ha). Young-of-the-year Freshwater Drum density (61/ha) declined from a big 2018 year class, well under the ten-year mean (99/ha). Young-of-the-year and age-1+ Trout-perch densities (24/ha and 25/ha, respectively) declined from 2018 numbers; adults were well above the ten-year mean (18/ha), while age-0 fish were well below (89/ha).

2.4.2 Michigan Lake Erie Forage Trawls (J. Hessenauer)

Michigan initiated a trawling program to assess the forage and age-0 sportfish community in Michigan waters of Lake Erie in August of 2014. This assessment samples eight two-minute index grids for one five- or ten-minute tow, typically sampling an area of approximately 0.2-0.4 ha depending on tow time. Our otter trawl has a 10 meter head rope and 9.5 mm terminal mesh and is deployed with a single warp and 45.7 meter bridle. Captured fish are passed through a 3.18-cm screen to grade out forage and age-0 sportfish. In 2019 all eight sites (Figure 2.4.7) were sampled between August 5th and August 7th.

The 2019 trawl survey saw a return to typical catches of forage after the high observed in 2018, with the catch of forage sized individuals averaging 1,988.5 fish per hectare trawled (fish/ha). This represents the second highest catch of our time series but represents a considerable decline from the high of 10,603 fish/ha observed last year (Table 2.4.4). Age-0 Yellow Perch (1,291/ha) and White Perch (389.1/ha) were the most abundant forage sized fish captured, though both were down considerably from last year (Table 2.4.4). Shiner species including Emerald Shiners (11.4/ha), Mimic Shiners (141.5/ha), and Spottail Shiners (10.6/ha) all increased compared to 2018 (Table 2.4.4). Finally, age-0 Walleye were again at their highest observed abundance in 2019 (68.5/ha trawled, Table 2.4.4) indicating another strong year hatch of Walleyes in the Michigan waters of Lake Erie.

The continued development of this dataset will allow for the evaluation of trends in forage abundance and the recruitment of sportfishes in Michigan's Lake Erie waters in future years. Based on the current time series, 2019 appears to have been an exceptional year for the production of age-0 Walleye in Michigan's Lake Erie waters, while Yellow Perch and White Perch returned to more typical abundances. Michigan plans to continue forage trawling at these sites annually to contribute to lake wide estimates of forage and age-0 sportfish abundance.

2.5 Diet and Growth of Predators

2.5.1 Eastern Basin Predator Diet and Growth (J. Markham)

Diet

Beginning in 1993, annual, summertime (June-August) visits were made to fish cleaning stations by the NYSDEC to gather stomach content information from angler-caught Walleye in the New York waters of Lake Erie. During 2019, 357 Walleye stomachs were examined of which 97 (28%) contained food remains. Round Goby were the dominant Walleye diet item by volume for angler-caught adult Walleye in 2019, while Rainbow Smelt contributed a record low 2% (Figure 2.5.1.1). The contribution by volume of identifiable species included three identifiable fish species: Round Goby (69%), Rainbow Smelt (2%), and Yellow Perch (21%). Also of note was the presence of zooplankton in Walleye stomachs (6% by volume), which is a rare occurrence but has been present for the past three years.

Seasonal diet information for Lake Trout is not available based on current sampling protocols. Diet information was limited to fish caught during August 2019 (N=412) in the interagency Coldwater Assessment (CWA) survey in the eastern basin of Lake Erie. Rainbow Smelt have traditionally been the main prey item for Lake Trout and often account for over 90% of Lake Trout diet items. However, Round Goby have become a common prey item since they invaded the east basin of Lake Erie in the early 2000s. In years of lower adult Rainbow Smelt abundance, Lake Trout prey more on Round Goby.

In 2019, Rainbow Smelt and Round Goby were again the prominent diet items for Lake Trout, occurring in 61% and 37% of the stomachs, respectively (Figure 2.5.1.2). It should be noted that Round Goby were much more numerically abundant in Lake Trout diets compared to Rainbow Smelt; some Lake Trout stomachs contained in excess of 50 Round Goby compared to a few adult smelt. Other fish species comprised 8% of the diets, which is the second highest occurrence in the time series. Yellow Perch comprised the majority of this group (5%); other species included *Morone* spp. (White Perch, White Bass; <1%), Freshwater Drum (<1%), White Sucker (<1%), Emerald Shiner (<1%), Clupeids (Gizzard Shad, Alewife; <1%), and a young-of0the-year Walleye (<1%). This was the first time that a Walleye or a White Sucker appeared in Lake Trout diets.

Similar to Lake Trout, the only diet information available for Burbot was collected during the CWA survey. Analysis of stomach contents (N=12) revealed a diet comprised mostly of fish. Burbot diets continue to be diverse, with four different identifiable fish species found in stomach samples. Round Goby was the dominant prey item, occurring in 50% of Burbot diet samples; other species detected were Rainbow Smelt (8%), Yellow Perch (8%), and *Morone spp.* (8%; Figure 2.5.1.3). Round Goby have become the dominate prey species for Burbot in most years since 2003.

Growth

Walleye length at age-1 and age-2 from netting surveys targeting juveniles in New York had remained relatively stable for the past decade but has declined in the past three years. In 2019, age-1 and age-2 Walleye were 1.2 and 1.1 inches below the long-term average length, respectively; both metrics ranked near the lowest observed in the 38-year time series (Robinson 2020). In general, age-0 and age-1 Yellow Perch have exhibited stable growth rates over the past ten years. In 2019, age-0 Yellow Perch were 0.3 inches below their time series average and were the second lowest in the 28-year time series while age-1 fish were below average and at their smallest length-at-age since 2005 (Markham and Robinson 2020).

2.5.2 Central Basin Predator Diet and Growth (J. Deller)

Diet

Diets of adult Walleye are collected from the central basin fall gill net survey in Ohio waters. In 2019, Walleye diets consisted of Gizzard Shad (74%), unidentified fish (22%), Rainbow Smelt (3%) and Emerald Shiner (1%; Figure 2.5.2.1). Emerald Shiner and Rainbow Smelt have contributed up to 30% and 12%, respectively, of Walleye diets in previous years. Contributions from both species to Walleye diets have declined since 2017.

Growth

Growth rates of age-0 Walleye declined from 2018 and were below the long-term mean. Young-of-the-year Walleye growth rates have been below long-term means since 2015. Mean length of age-0 Walleye was the lowest in the time series, most likely due to the exceptional cohort in 2019. Growth rates of most age-0 forage species in 2019 were at or above long-term means. Mean length at age for Walleye cohorts through age-6 have declined from 2018 and are generally below long-term means. Mean length of Yellow Perch cohorts through age-6 have generally increased from 2018 and are above long-term means.

2.5.3 Western Basin Predator Diet and Growth (Z. Slagle)

Diet

In 2019, age-1 Walleye diets (by percent dry weight; 10 stomachs excluding empty) taken from ODNR fall gillnet catches consisted of Gizzard Shad (51%), Yellow Perch (7%), Round Goby (2%), and unidentifiable fish remains (39%) in the western basin. Adult Walleye (73 stomachs excluding empty) relied on Gizzard Shad (69%), Rainbow Smelt (2%), and unidentifiable fish remains (29%). No age-0 Walleye diets were taken from the fall gillnet survey in 2019.

USGS collected stomachs from all ages of Yellow Perch captured in bottom trawls from 41 sites throughout the western basin in June and September 2019. Captured fishes were dissected in the field immediately after capture. Stomach contents were placed in Whirl-Pak bags and frozen at -80° C, then transferred to -20° C after flash freezing. Contents were processed in the lab. Prey items were identified to the lowest taxonomic level possibly by coarse visual inspection (i.e., no effort was made to use taxonomic keys to identify species of *Hexagenia* spp.), dried in a Heratherm drying oven at 60°C until a constant mass was achieved, then weighed to the nearest 0.001 g. USGS collected 62 diets in June (0 empty) and 82 diets in September (13 empty, 69 full). Analyses below are based on stomachs containing food.

Yellow Perch diet content varied seasonally for food item frequency of occurrence. In June, perch diets were dominated by benthic invertebrates (found in 85% of diets), followed by zooplankton (34%) and fish (16%). Benthic macroinvertebrates and zooplankton were both found in high frequency in Yellow Perch diets in September (51% and 75%, respectively; Figure 2.5.3.1). Specifically, in June the most common prey items were lake flies (Chironomidae; 53%), mayflies (Ephemeridae; 37%), caddisflies (Tricoptera; 29%), *Bythotrephes* spp. (19%), and *Daphnia* spp. (18%). In September, specific diet items changed to *Bythotrephes* spp. (62%), followed by *Daphnia* spp. (29%), lake flies (Chironomidae; 14%), and amphipods (11%; Figure 2.5.3.1).

Benthic macroinvertebrates (65%) contributed the most to Yellow Perch diet dry weight in June 2019, while zooplankton (60%) contributed the most in September (Figure 2.5.3.2). The largest proportions of dry weight in June by diet item were mayflies (Ephemeridae; 35%), Dreissenid mussels (28%), lake flies (Chironomidae; 11%), unidentified fishes (9%), and *Bythotrephes* spp. (9%). In September, diet dry weights were made up of *Bythotrephes* spp. (50%), snails (Gastropods; 20%), *Daphnia* spp. (9%), and mayflies (*Hexagenia* spp.; 7%).

Growth

Overall, mean length of age-0 sport fish in 2019 was similar to 2018 (Figure 2.5.3.3). Lengths of select age-0 species in 2019 include Walleye (101 mm), Yellow Perch (67 mm), White Bass (82 mm), and White Perch (70 mm). Walleye average length was the lowest in the time series and has declined for six consecutive years, likely due to high abundance of age-0 Walleye. White Bass have been well above the time series average for two years. Smallmouth Bass average length has been dropped from this reporting due to consistently small sample size within years.

Table 2.2.1: Relative abundance of selected forage fish species from bottom trawl surveys conducted by Ontario, New York, and Pennsylvania in the eastern basin of Lake Eire for the most recent 10-year period. Indices are reported as arithmetic mean number caught per hectare for young-of-the-year (YOY), yearling-and-older (YAO), and all ages (ALL). Long-term averages are reported as the mean of the annual trawl indices for the most recent 10-year period (2010-2019) and for the two most recent completed decades. Agency trawl surveys are described below.

	Age	Trawl											10-Yr & Long-term Avg. by decade		
Species	**Group**	**Survey**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**10-Yr**	**2000's**	**1990's**
Rainbow	**YOY**	ON-DW	326.9	509.2	1657.7	217.9	1001.6	3245.2	538.3	372.3	584.8	739.6	919.3	1267.2	431.7
Smelt	**YOY**	NY-Fa	1453.6	1621.7	424.4	755.2	5520.2	2930.7	2901.3	3225.3	861.7	1255.7	2095.0	1416.9	1468.0
	YOY	PA-Fa	NA	NA	560.2	NA	NA	129.1	166.9	872.3	NA	62.7	358.2	106.0	421.1
	YAO	ON-DW	222.7	277.1	367.8	165.3	4.6	411.0	20.2	0.1	0.1	11.3	148.0	490.1	358.6
	YAO	NY-Fa	1023.8	656.8	22.7	45.8	24.8	590.1	5.8	67.5	65.5	27.0	253.0	1004.2	583.3
	YAO	PA-Fa	NA	NA	22.3	NA	NA	39.6	0.0	0.5	NA	0.4	12.5	202.2	1108.8
Emerald	**YOY**	ON-DW	117.6	70.3	438.3	58.7	2.9	346.7	2.0	0	0.7	3.8	104.1	422.3	52.3
Shiner	**YOY**	NY-Fa	64.6	3006.7	96.8	130.9	526.3	137.6	6.1	51.6	23.8	5.6	405.0	174.4	115.1
	YOY	PA-Fa	NA	NA	14.8	NA	NA	68.2	0.0	0	NA	0.0	16.6	289.3	39.9
	YAO	ON-DW	30.7	201.1	119.2	188.6	2.5	6.5	28.2	0.4	1.3	12.5	59.1	741.1	37.7
	YAO	NY-Fa	21.1	1874.0	96.2	67.1	822.8	24.8	22.2	4.5	1108.3	95.9	413.7	294.4	108.1
	YAO	PA-Fa	NA	NA	86.9	NA	NA	146.9	0.0	0	NA	0.0	46.8	761.3	10.3
Spottail	**YOY**	ON-OB	3.0	2.5	19.1	8.1	5.0	5.8	4.1	38.2	36.7	27.5	15.0	107.7	815.9
	YOY	NY-Fa	6.7	0.7	1.8	0.0	0.1	0.0	0.1	0.4	3.5	2.7	1.6	5.7	20.4
	YOY	PA-Fa	NA	NA	0.0	NA	NA	0.0	0.0	0	NA	0.0	0.0	0.2	3.6
	YAO	ON-OB	2.1	0.5	1.6	3.0	0.2	1.5	0.0	2.8	3.3	9.2	2.4	10.1	74.6
	YAO	NY-Fa	10.7	29.7	2.1	0.3	0.2	0.0	9.3	0.8	6.2	2.1	6.1	6.6	4.0
	YAO	PA-Fa	NA	NA	0.1	NA	NA	0.0	0.0	0	NA	0.0	0.0	0.0	5.7
Alewife	**YOY**	ON-DW	0.9	2.1	707.3	17.7	0.0	0.7	0.8	36.1	0.0	0.0	76.6	20.2	231.2
	YOY	ON-OB	0.0	6.8	6.0	26.1	0.0	3.4	0.0	28.3	0.0	0.7	7.1	74.1	88.5
	YOY	NY-Fa	15.8	12.7	188.6	223.9	0.0	5.6	0.8	297.7	8.7	0.8	75.5	87.0	53.4
	YOY	PA-Fa	NA	NA	4.6	NA	NA	0.0	0.0	0	NA	0.0	1.1	1.0	2.2
Gizzard	**YOY**	ON-DW	13.3	18.9	47.6	0.0	0.0	0.4	1.9	1.9	0.0	0.0	8.4	19.2	7.5
Shad	**YOY**	ON-OB	3.8	3.4	20.0	0.3	0.4	10.1	0.0	4.1	1.6	4.0	4.8	6.9	13.4
	YOY	NY-Fa	42.0	15.4	4.9	3.9	0.6	3.3	1.9	3.8	2.1	2.0	8.0	11.6	4.4
	YOY	PA-Fa	NA	NA	1.0	NA	NA	41.5	0.0	0	NA	0.0	10.6	0.0	0.3
White	**YOY**	ON-DW	1.6	0.0	0.8	0.0	0.0	0.5	96.1	0.3	1.0	1.3	10.2	2.7	1.8
Perch	**YOY**	ON-OB	0.0	0.0	0.9	0.0	0.0	0.2	0.0	0.7	38.6	1.2	4.2	2.5	17.6
	YOY	NY-Fa	161.3	37.5	18.7	4.5	36.1	17.3	79.3	44.2	43.2	96.5	53.9	70.7	30.1
	YOY	PA-Fa	NA	NA	380.0	NA	NA	287.9	2.3	150.4	NA	70.5	205.1	267.8	71.5
Trout	**All**	ON-DW	0.3	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.1	0.9	0.6
Perch	**All**	NY-Fa	473.7	671.4	347.8	152.7	64.9	33.1	26.1	8.6	6.6	6.9	179.2	815.0	417.5
	All	PA-Fa	NA	NA	52.2	NA	NA	2.1	0.2	4.2	NA	0.2	11.8	179.5	64.6
Yellow	**YOY**	ON-Comp	51.8	176.7	27.4	0.5	28.4	58.5	360.6	65.5	328.8	227.0	132.5	33.0	79.5
Perch	**YOY**	NY-Fa	197.7	89.5	280.0	4.4	274.2	68.6	2178.2	247.0	662.4	169.1	417.1	40.2	251.0
	YOY	PA-Fa	NA	NA	286.8	NA	NA	69.3	56.3	300.4	NA	27.7	148.1	259.8	27.4
Round	**All**	ON-DW	9.7	125.4	129.0	14.5	0.5	67.2	300.9	137.9	64.2	194.2	104.3	216.7	0.0
Goby	**All**	ON-OB	67.6	103.3	68.0	76.3	98.5	359.1	54.0	93.5	315.1	34.4	127.0	87.3	0.1
	All	ON-IB	135.1	114.6	80.2	49.6	95.4	151.6	160.8	28.2	110.5	80.9	100.7	136.1	0.1
	All	NY-Fa	177.81	170.15	184.89	86.06	140.33	441.58	104.9	146.9	164.5	204.1	182.1	656.0	1.0
	All	PA-Fa	NA	NA	32.1	NA	NA	47.2	85.6	30.1	NA	20.9	43.2	1002.4	42.0

"**NA**" denotes that reporting of indices was Not Applicable or that data were Not Available.

Ontario Ministry of Natural Resources and Forestry Trawl Surveys

ON-DW Trawling conducted weekly in October at 4 fixed stations in offshore waters of Outer Long Point Bay using a 10-m trawl with 13-mm mesh cod end liner.

ON-OB Trawling conducted weekly in September and October at 3 fixed stations in nearshore waters of Outer Long Point Bay using a 6.1-m trawl with a 13-mm mesh cod end liner.

ON-IB Trawling conducted weekly in September and October at 4 fixed stations in Inner Long Point Bay using a 6.1-m trawl with a 13-mm mesh cod end liner.

ON-Comp The mean of all three ON trawl surveys weighted by surface area.

New York State Department of Environment Conservation Trawl Survey

NY-Fa Trawling is conducted at approximately 30 nearshore (15-30 m) stations during October using a 10-m trawl with a 9.5-mm mesh cod end liner. 90's Avg. is for the period 1992 to 1999.

Pennsylvania Fish and Boat Commission Trawl Survey

PA-Fa Trawling is conducted at nearshore (< 22 m) and offshore (> 22 m) stations during October using a 10-m trawl with a 6.4-mm mesh cod end liner.

Table 2.3.1: Catch per hectare (arithmetic mean) of selected age-0 species from fall trawl surveys conducted in the Ohio and Pennsylvania waters of the central basin, Lake Erie, from 2009-2019. Ohio West (OH West) is the area from Huron, OH, to Fairport Harbor, OH. Ohio East (OH East) is the area from Fairport Harbor, OH to the Ohio-Pennsylvania state line. PA is the area from the Ohio-Pennsylvania state line to Presque Isle, PA.

		Year											
Species	Survey	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Mean
Yellow	OH West	1.6	41.1	10.3	69.2	8.9	37.7	19.6	0.5	19.0	28.4	0.2	23.6
Perch	OH East	0.5	96.3	15.1	134.4	8.9	49.1	18.6	1.6	39.1	50.8	8.0	41.4
	PA	14.2	-	-	481.6	28.0	-	107.0	332.9	92.9	6.0	35.5	151.8
White	OH West	379.0	254.8	346.6	1709.6	174.7	135.0	371.0	15.3	200.8	163.1	10.8	375.0
Perch	OH East	34.6	190.3	72.1	661.9	200.1	99.4	338.8	5.4	44.4	248.8	67.6	189.6
	PA	146.3	-	-	380.1	2.2	-	758.6	165.5	149.3	176.0	305.6	254.0
Rainbow	OH West	267.8	776.2	29.8	84.4	126.0	747.8	447.0	219.4	347.1	1.7	132.5	304.7
Smelt	OH East	0.3	421.6	247.3	319.1	12.8	1709.5	236.4	1383.4	898.7	1.7	304.4	523.1
	PA	23.1	-	-	10.4	132.8	-	148.1	506.4	319.4	7.3	156.0	163.9
Round	OH West	24.5	28.4	100.8	18.2	17.5	6.3	56.8	14.5	27.3	2.8	14.6	29.7
Goby	OH East	1.0	41.8	256.0	53.9	45.8	86.2	66.8	29.9	31.1	4.2	13.1	61.7
	PA	72.0	-	-	3.3	11.7	-	124.1	47.2	210.3	110.1	10.9	82.7
Emerald	OH West	7.5	8.8	361.7	951.3	2218.5	1369.3	3.5	0.0	0.0	1.3	0.0	492.2
Shiner	OH East	1.7	234.9	103.7	2188.5	306.2	650.1	13.2	0.0	0.0	0.0	0.0	349.8
	PA	304.6	-	-	0.0	31.6	-	57.7	2.2	0.0	0.0	0.1	56.6
Spottail	OH West	0.4	0.0	0.6	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.4
Shiner	OH East	0.0	0.0	0.3	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.1
	PA	0.0	-	-	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0
Alewife	OH West	0.0	0.0	0.0	0.0	52.1	0.0	0.0	0.0	30.3	0.0	0.0	8.2
	OH East	0.0	0.0	0.0	0.1	36.1	0.0	0.0	0.0	223.6	0.0	0.0	26.0
	PA	0.0	-	-	2.8	5.0	-	0.0	4.0	0.0	0.0	0.6	1.7
Gizzard	OH West	52.6	2.6	675.8	98.7	304.2	33.8	568.0	12.0	201.6	13.7	9.7	196.3
Shad	OH East	3.9	8.5	4.2	28.7	39.5	7.3	455.6	1.2	214.8	12.3	14.2	77.6
	PA	0.0	-	-	0.0	0.0	-	8.7	0.0	0.5	0.0	0.0	1.3
Trout-	OH West	0.5	0.7	1.3	0.0	0.1	0.3	0.4	0.0	0.0	0.0	0.0	0.3
perch	OH East	0.2	1.4	2.2	0.2	0.0	0.6	1.2	0.0	0.2	0.0	0.1	0.6
	PA	28.2	-	-	0.0	0.0	-	2.2	4.6	4.2	0.0	2.8	5.6

\- The Pennsylvania Fish and Boat Commission was unable to sample in these years.

Table 2.3.2: Catch per hectare (arithmetic mean) of selected age-1+ species from fall trawl surveys conducted in the Ohio and Pennsylvania waters of the central basin, Lake Erie, from 2009-2019. Ohio West (OH West) is the area from Huron, OH, to Fairport Harbor, OH. Ohio East (OH East) is the area from Fairport Harbor, OH to the Pennsylvania state line. PA is the area from the Ohio-Pennsylvania state line to Presque Isle, PA.

		Year											
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Mean
Species	Survey												
Yellow	OH West	20.2	11.9	6.3	7.4	34.9	15.4	41.3	5.0	3.7	7.9	1.1	15.4
Perch	OH East	139.4	12.4	55.5	23.3	109.5	24.2	30.2	8.7	7.6	6.6	4.8	41.7
	PA	121.8	-	-	117.7	73.7	-	59.0	61.2	114.1	24.8	7.8	81.8
White	OH West	45.8	32.6	25.9	45.8	195.9	5.8	1.7	47.5	29.9	3.5	7.0	43.4
Perch	OH East	282.3	44.8	49.8	7.7	546.9	4.4	1.4	55.4	17.6	6.6	20.7	101.7
	PA	62.6	-	-	7.8	18.4	-	78.9	4.0	19.6	0.9	11.1	27.5
Rainbow	OH West	368.8	9.0	15.6	9.1	8.1	34.9	340.8	0.5	53.8	16.7	13.0	85.7
Smelt	OH East	98.2	49.8	186.0	95.4	200.7	6.2	295.4	17.1	35.7	9.4	0.3	99.4
	PA	406.5	-	-	20.5	25.1	-	69.7	5.0	0.9	0.0	0.5	75.4
Round	OH West	60.4	44.0	68.6	11.8	24.3	6.9	35.8	3.7	19.6	4.5	9.9	28.0
Goby	OH East	19.3	36.0	118.1	27.0	46.3	89.1	72.4	16.1	14.3	3.5	22.9	44.2
	PA	76.0	-	-	72.9	8.6	-	50.3	12.7	183.9	30.9	4.8	62.2
Emerald	OH West	127.7	51.5	138.2	998.8	298.0	55.8	0.9	1.3	0.0	0.0	0.0	167.2
Shiner	OH East	167.8	375.1	149.7	433.2	8.4	333.5	1.8	0.0	0.0	0.0	0.0	147.0
	PA	172.5	-	-	8.9	17.2	-	179.5	6.4	0.0	0.0	0.0	54.9
Spottail	OH West	1.9	0.0	20.7	0.0	0.5	1.7	0.0	0.0	0.0	0.7	0.0	2.6
Shiner	OH East	0.0	0.0	3.1	3.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.9
	PA	0.0	-	-	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0
Trout-	OH West	0.9	0.7	3.3	1.6	3.3	0.6	0.7	0.0	0.4	2.0	0.6	1.4
perch	OH East	1.5	5.0	7.9	11.7	1.0	0.4	3.0	0.1	0.3	5.3	2.2	3.6
	PA	127.5	-	-	30.4	9.3	-	8.3	2.4	5.2	0.0	8.0	26.2

- The Pennsylvania Fish and Boat Commission was unable to sample in these years.

Table 2.4.1: Mean catch-per-unit-effort (CPUE; #/ha) and fishing power correction factors (FPC) by vessel-species-age group combinations. All FPCs are calculated relative to the R./V. *Keenosay*.

Vessel	Species	Age group	Trawl Hauls	Mean CPUE	FPC	95% CI	Apply rule [a]
R.V. Explorer	Gizzard Shad	Age 0	22	11.8	2.362	-1.26-5.99	Y
	Emerald Shiner	Age 0+	50	67.8	1.494	0.23-2.76	Y
	Trout-Perch	Age 0+	51	113.2	0.704	0.49-0.91 z	Y
	White Perch	Age 0	51	477.2	1.121	1.01-1.23 z	Y
	White Bass	Age 0	50	11.7	3.203	0.81-5.60	Y
	Yellow Perch	Age 0	51	1012.2	0.933	0.62-1.24	N
	Yellow Perch	Age 1+	51	119.6	1.008	0.72-1.30	N
	Walleye	Age 0	51	113.7	1.561	1.25-1.87 z	Y
	Round Goby	Age 0+	51	200.3	0.423	0.22-0.63 z	Y
	Freshwater Drum	Age 1+	51	249.1	0.598	0.43-0.76 z	Y
R.V. Gibraltar	Gizzard Shad	Age 0	29	14.2	1.216	-0.40-2.83	Y
	Emerald Shiner	Age 0+	43	51.3	2.170	0.48-3.85	Y
	Trout-Perch	Age 0+	45	82.1	1.000	0.65-1.34	N
	White Perch	Age 0	45	513.5	0.959	0.62-1.30	N
	White Bass	Age 0	45	21.9	1.644	0.00-3.28	Y
	Yellow Perch	Age 0	45	739.2	1.321	0.99-1.65	Y
	Yellow Perch	Age 1+	45	94.6	1.185	0.79-1.58	Y
	Walleye	Age 0	45	119.2	1.520	1.17-1.87 z	Y
	Round Goby	Age 0+	45	77.4	0.992	0.41-1.57	N
	Freshwater Drum	Age 1+	45	105.2	1.505	1.10-1.91 z	Y
R.V. Grandon	Gizzard Shad	Age 0	29	70.9	0.233	-0.06-0.53 z	Y
	Emerald Shiner	Age 0+	34	205.4	0.656	-0.04-1.35	Y
	Trout-Perch	Age 0+	35	135.9	0.620	0.42-0.82 z	Y
	White Perch	Age 0	36	771.4	0.699	0.44-0.96 z	Y
	White Bass	Age 0	36	34.9	0.679	0.43-0.93 z	Y
	Yellow Perch	Age 0	36	1231.6	0.829	0.58-1.08	Y
	Yellow Perch	Age 1+	36	123.4	0.907	0.58-1.23	Y
	Walleye	Age 0	36	208.6	0.920	0.72-1.12	Y
	Round Goby	Age 0+	36	161.8	0.501	0.08-0.92 z	Y
	Freshwater Drum	Age 1+	36	58.8	2.352	1.51-3.19 z	Y
R.V. Musky II	Gizzard Shad	Age 0	24	8.8	1.885	-1.50-5.26	Y
	Emerald Shiner	Age 0+	47	32.3	3.073	0.36-5.79	Y
	Trout-Perch	Age 0+	50	62.4	1.277	0.94-1.62	Y
	White Perch	Age 0	50	255.7	2.091	1.37-2.81 z	Y
	White Bass	Age 0	46	8.4	4.411	0.90-7.92	Y
	Yellow Perch	Age 0	50	934.0	1.012	0.77-1.26	N
	Yellow Perch	Age 1+	50	34.9	3.452	1.23-5.67 z	Y
	Walleye	Age 0	50	63.7	2.785	2.24-3.33 z	Y
	Round Goby	Age 0+	49	66.9	1.266	0.39-2.14	Y
	Freshwater Drum	Age 1+	49	1.6	93.326	48.39-138.26 z	Y

z - Indicates statistically significant difference from 1.0 (α=0.05); [a] Y means decision rule indicated FPC application was warranted; , N means decision rule indicated FPC application was not warranted

Table 2.4.2: Ten-year mean relative abundance (arithmetic mean number per hectare), 2019 relative abundance, and the percent difference between 2019 and the ten-year average for forage fish functional groups from fall trawl surveys in the western basin Lake Erie. Data are collected by OMNRF and ODNR and combined using FPC factors.

Functional Group	Mean: 2008-2018	2019	+/-
All	5029.3	2633.2	-48%
Clupeid	914.5	39.2	-96%
Soft-Rayed	478.1	99.2	-79%
Spiny-Rayed	3636.8	2494.8	-31%

Table 2.4.3: Ten-year mean relative abundance (arithmetic mean number per hectare), 2019 relative abundance, and the percent difference between 2019 and the ten-year average for selected forage species from fall trawl surveys in the western basin Lake Erie. Data are collected by OMNRF and ODNR and combined using FPC factors.

Species	Age class	Mean: 2008-2018	2019	+/-
Emerald Shiner	Age-0	56.5	0.4	-99%
Emerald Shiner	Age-1+	62.0	0.1	-100%
Freshwater Drum	Age-0	99.5	61.1	-39%
Gizzard Shad	Age-0	914.5	39.2	-96%
Rainbow Smelt	Age-0	181.4	10.6	-94%
Rainbow Smelt	Age-1+	8.7	0.0	-100%
Round Goby	All ages	30.9	16.9	-45%
Walleye	Age-0	45.8	225.3	392%
White Bass	Age-0	130.3	79.9	-39%
White Perch	Age-0	2960.8	1573.0	-47%
Yellow Perch	Age-0	400.5	555.5	39%

Table 2.4.4: Mean density (number of fish per hectare) of forage sized and age-0 sportfish captured during the Michigan trawl survey. Forage sized and age-0 individuals are graded through a 3.18-cm screen.

Common Name	**Age Group**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Brook Silverside	All	0	0	8.1	0	0	0
Emerald Shiner	All	2.1	0	0	0	7.2	11.4
Channel Catfish	YOY	0	0	0	0	0	1.6
Freshwater Drum	YOY	29.4	6.9	6.3	0	45.6	7.9
Gizzard Shad	YOY	55.4	2.7	11.4	730.9	259.4	0.5
Johnny Darter	All	0	0	0	0	0.3	0
Logperch	All	1.9	14.8	3.1	4.4	2.3	2.2
Mimic Shiner	All	5.3	617.9	170.6	120.2	40.1	141.5
Rainbow Smelt	YOY	0.3	2.7	0	2.2	0	0
Rock Bass	YOY	0	0	0.2	0	0.5	0
Round Goby	All	43.4	135.8	19.2	41.4	58.6	24.7
Silver Chub	All	0	11.3	0.6	3.4	5.9	5.2
Smallmouth Bass	YOY	5.4	0.3	1.9	0	3.2	0
Spottail Shiner	All	54.2	18.8	26.6	2.2	6.3	10.6
Trout-Perch	All	25.6	16.8	68.8	62.1	290.4	19.0
Tubenose Goby	All	0	0	1.9	2.2	1.7	0
Walleye	YOY	0.6	4.8	3	16.6	50.3	68.5
White Bass	YOY	1.2	7	8.4	101.8	48.2	15.5
White Perch	YOY	715.5	783.2	448.5	1896.4	8100	389.1
White Sucker	YOY	0.3	0	0	0	0	0
Yellow Perch	YOY	129.5	335.8	424.4	331.6	1683	1291
GRAND TOTAL	-	1070.1	1958.8	1203.0	3315.4	10603.0	1988.5
Dreissened mussels*	All	0.41	0.55	0.81	0.45	0.60	0.66

*Dreissened mussels reported as kilograms captured per ha trawled and are not included in the Grand Total catch per ha values.

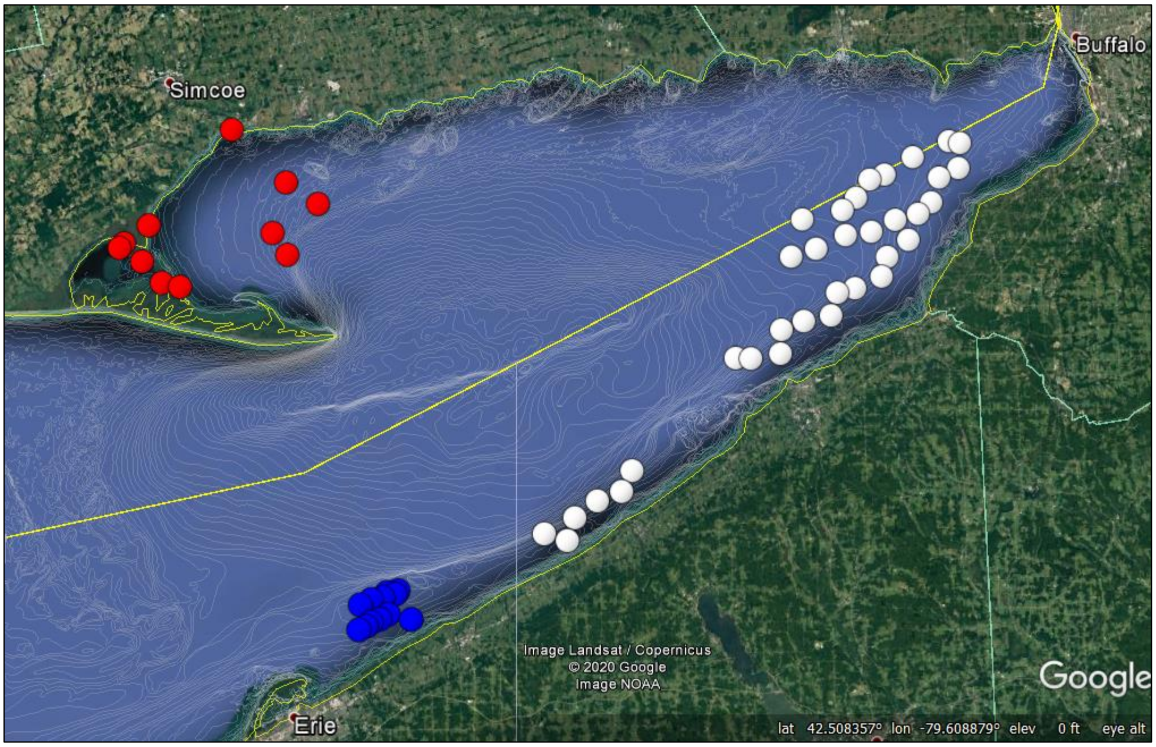


Figure 2.2.1: Locations samples with standard index bottom trawls by Ontario (OMRNF; red circles), New York (NYSDEC; white circles), and Pennsylvania (PFBC; blue circles) to assess forage fish abundance in the east basin of Lake Erie in 2019.

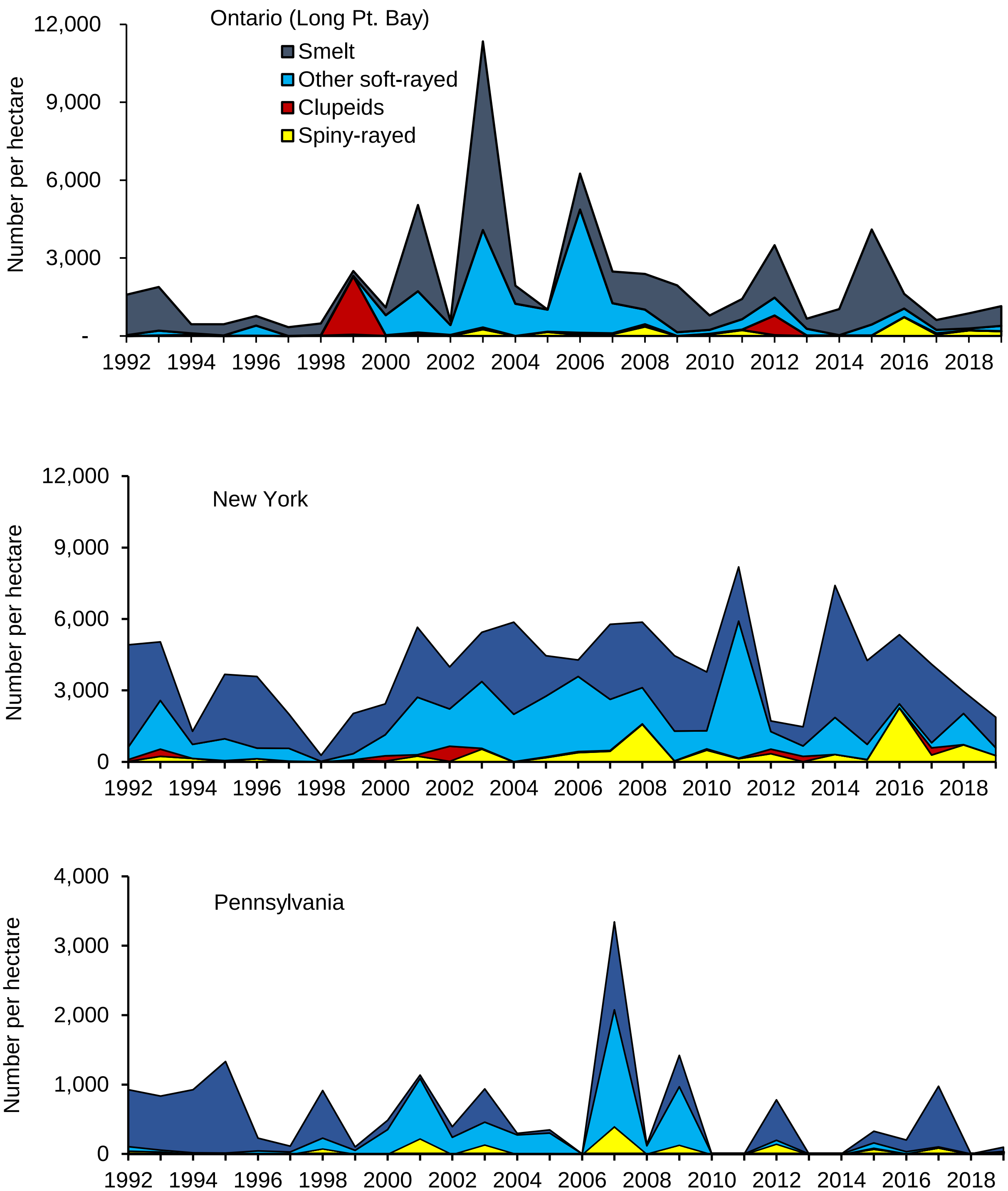


Figure 2.2.2: Mean density of prey fish (number per hectare) by functional group in the Ontario, New York, and Pennsylvania waters of the eastern basin, Lake Erie, 1992-2019. Note that the y-axis values are lower for Pennsylvania. Pennsylvania did not sample in 2010, 2011, 2013, 2014 or 2018.

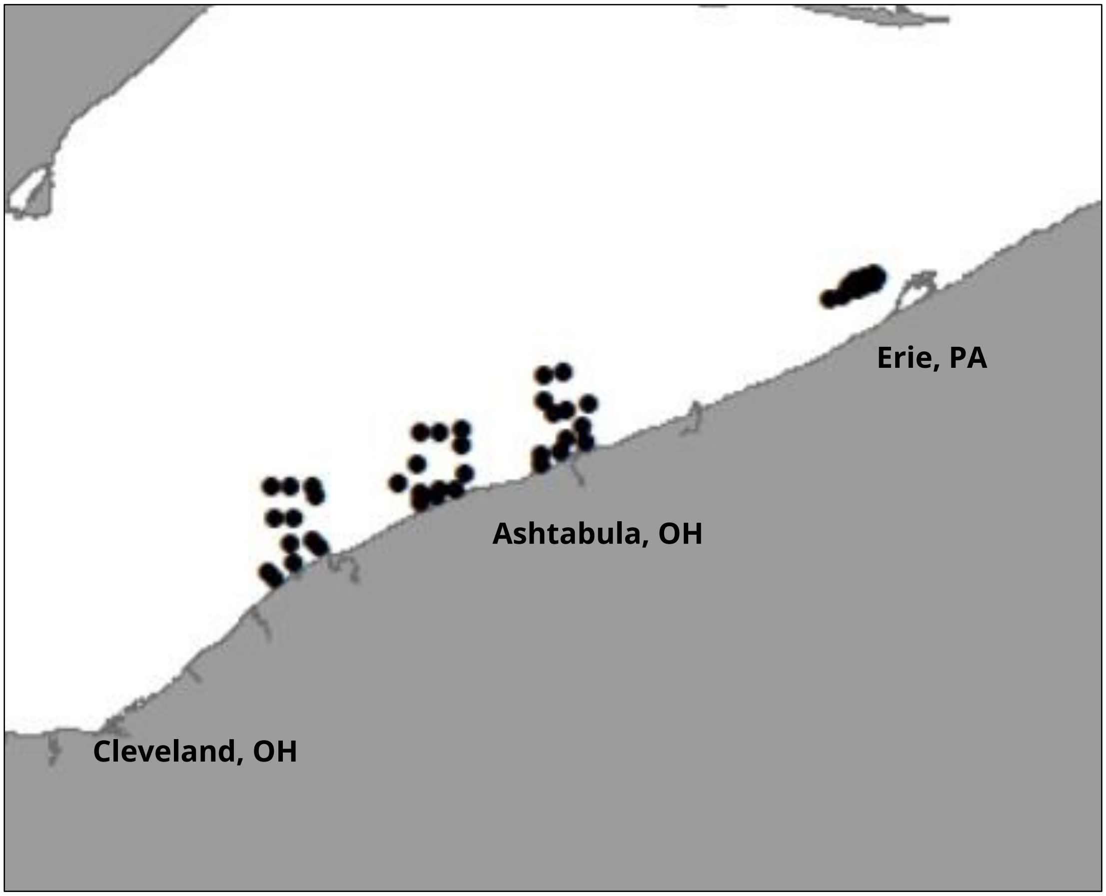


Figure 2.3.1: Locations sampled with index bottom trawls to assess forage fish abundance in the central basin, Lake Erie during 2019.

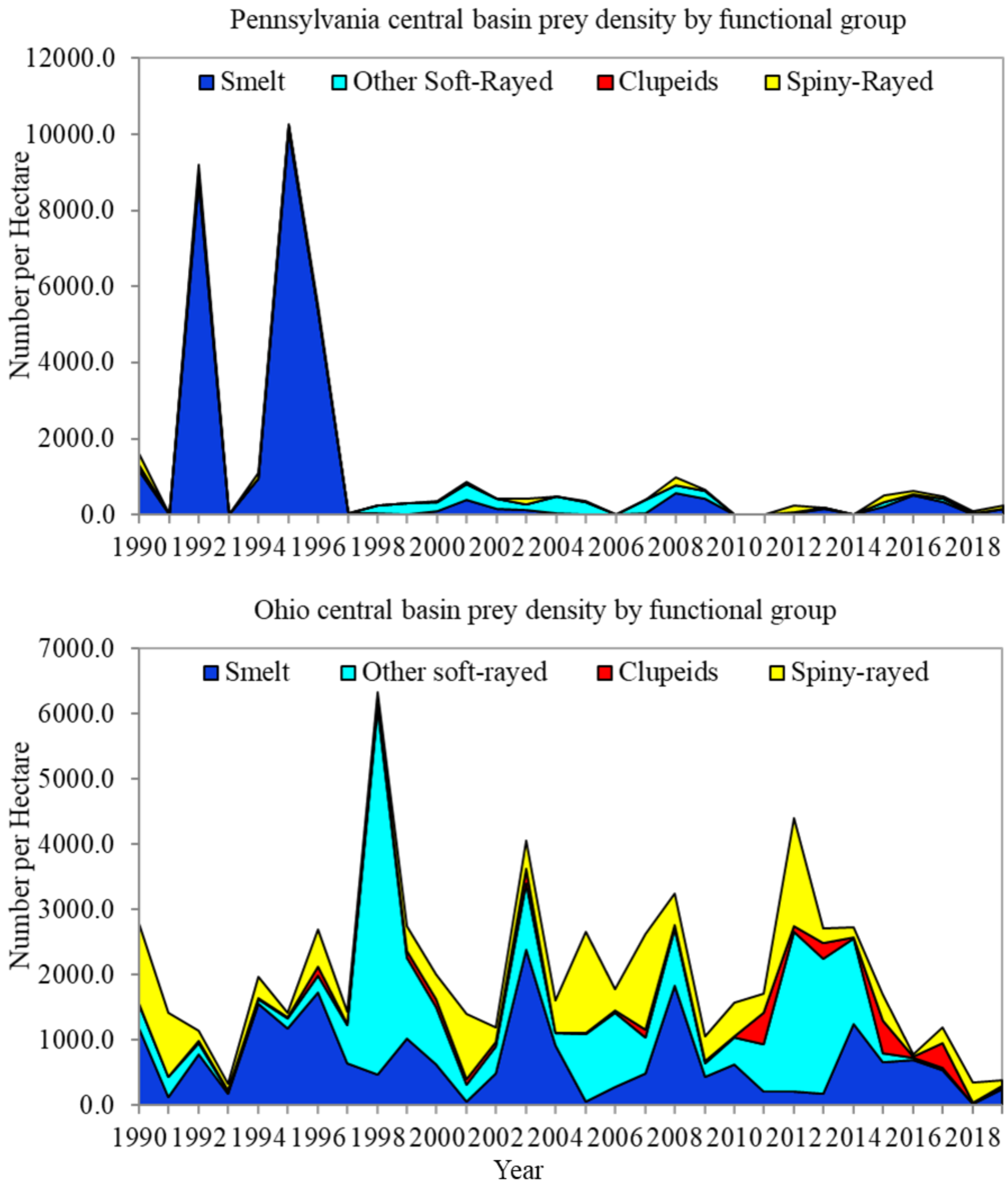


Figure 2.3.2: Mean density of prey fish (number per hectare) by functional group in Pennsylvania and Ohio waters of the central basin, Lake Erie, 1990-2019.

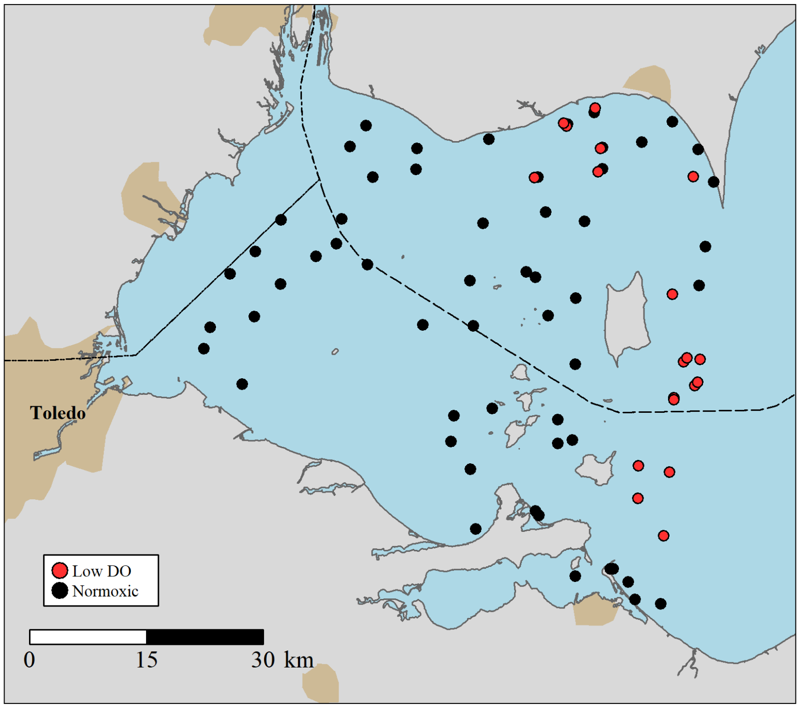


Figure 2.4.1: Trawl locations for the western basin interagency bottom trawl survey, August 2019. Low dissolved oxygen sites (< 2.0 mg/L; red) were removed from forage summaries (n = 20).

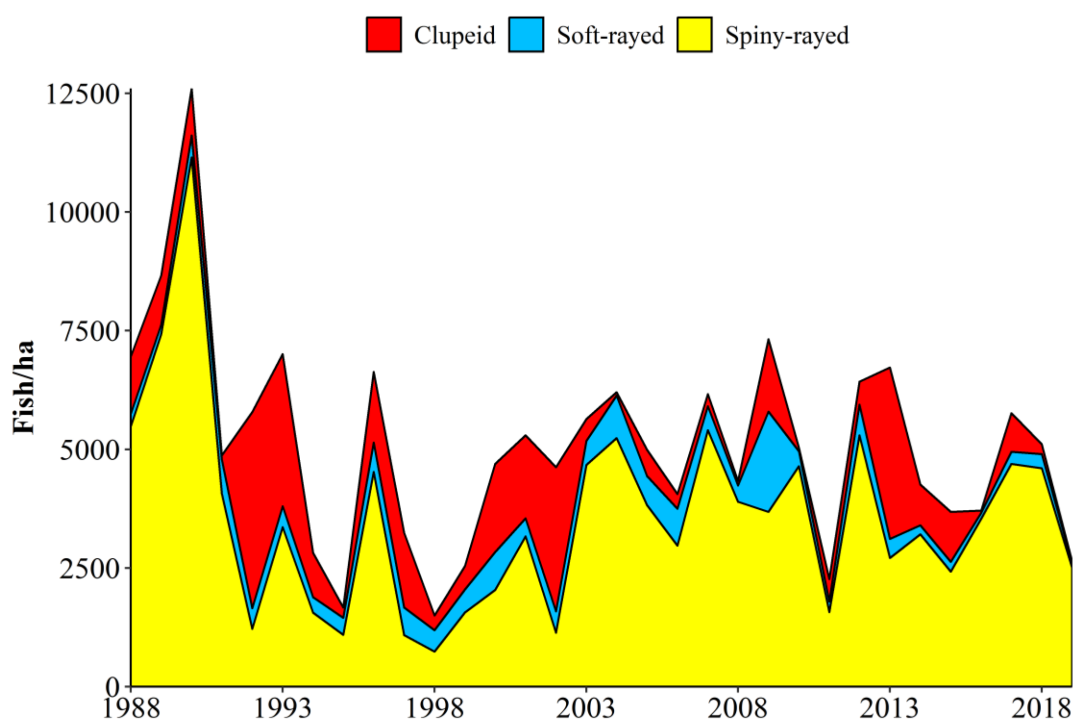


Figure 2.4.2: Mean density (number per hectare) of prey fish by functional group in western Lake Erie, August 1988-2019.

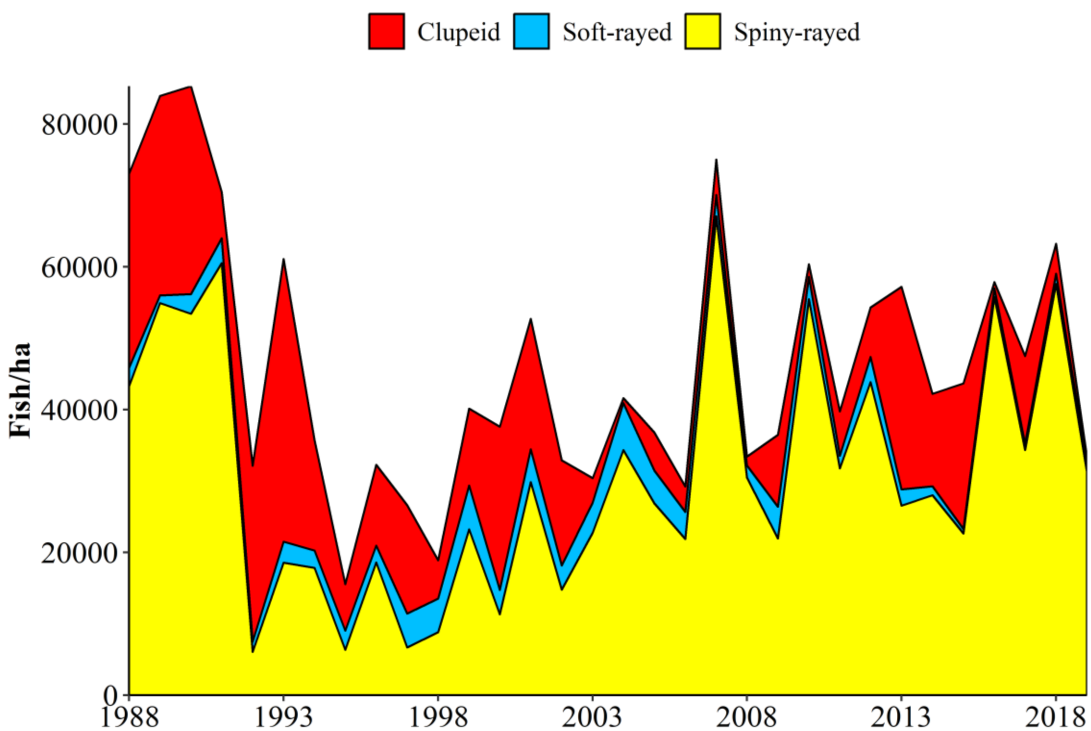


Figure 2.4.3: Mean biomass (tonnes) of prey fish by functional group in western Lake Erie, August 1988-2019.

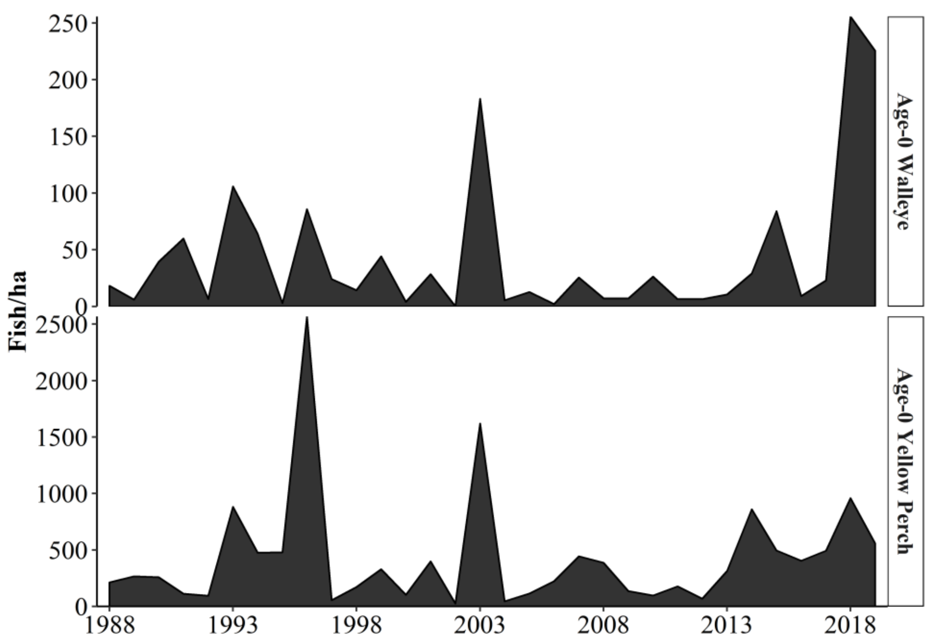


Figure 2.4.4: Densities of age-0 Walleye (top) and Yellow Perch (bottom) in the western basin of Lake Erie, August 1988-2019. The 2018 and 2019 Walleye year classes were the largest on record.

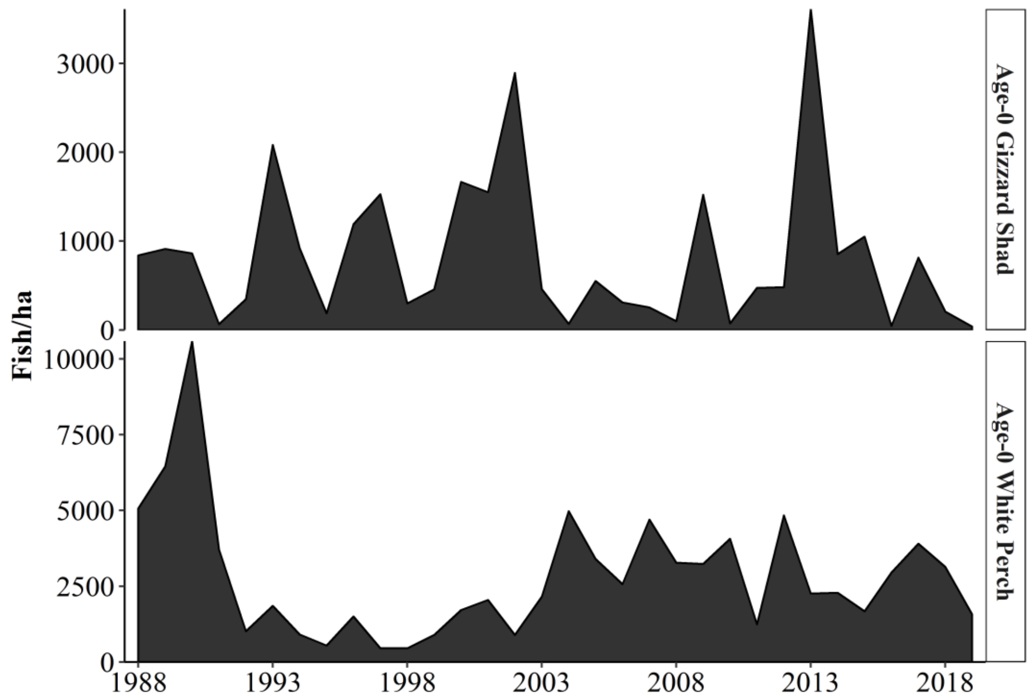


Figure 2.4.5: Density of age-0 Gizzard Shad (top) and White Perch (bottom) in the western basin of Lake Erie, August 1988-2019.

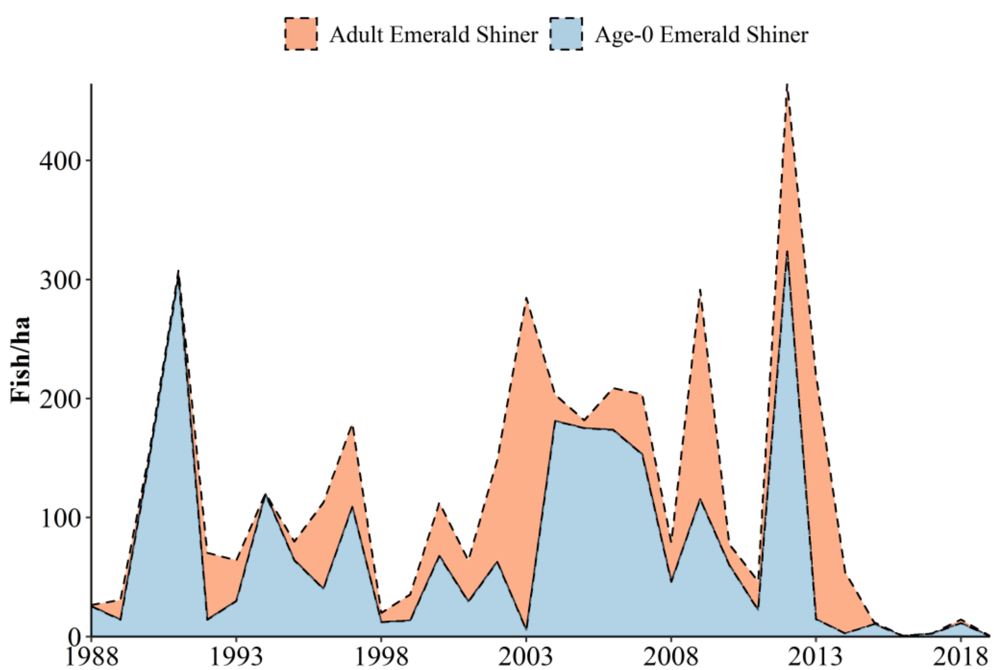


Figure 2.4.6: Densities of age-0 (blue) and age-1+ (red) Emerald Shiners in the western basin of Lake Erie, August 1988-2019. Densities for both groups in 2019 were the lowest in the time series.

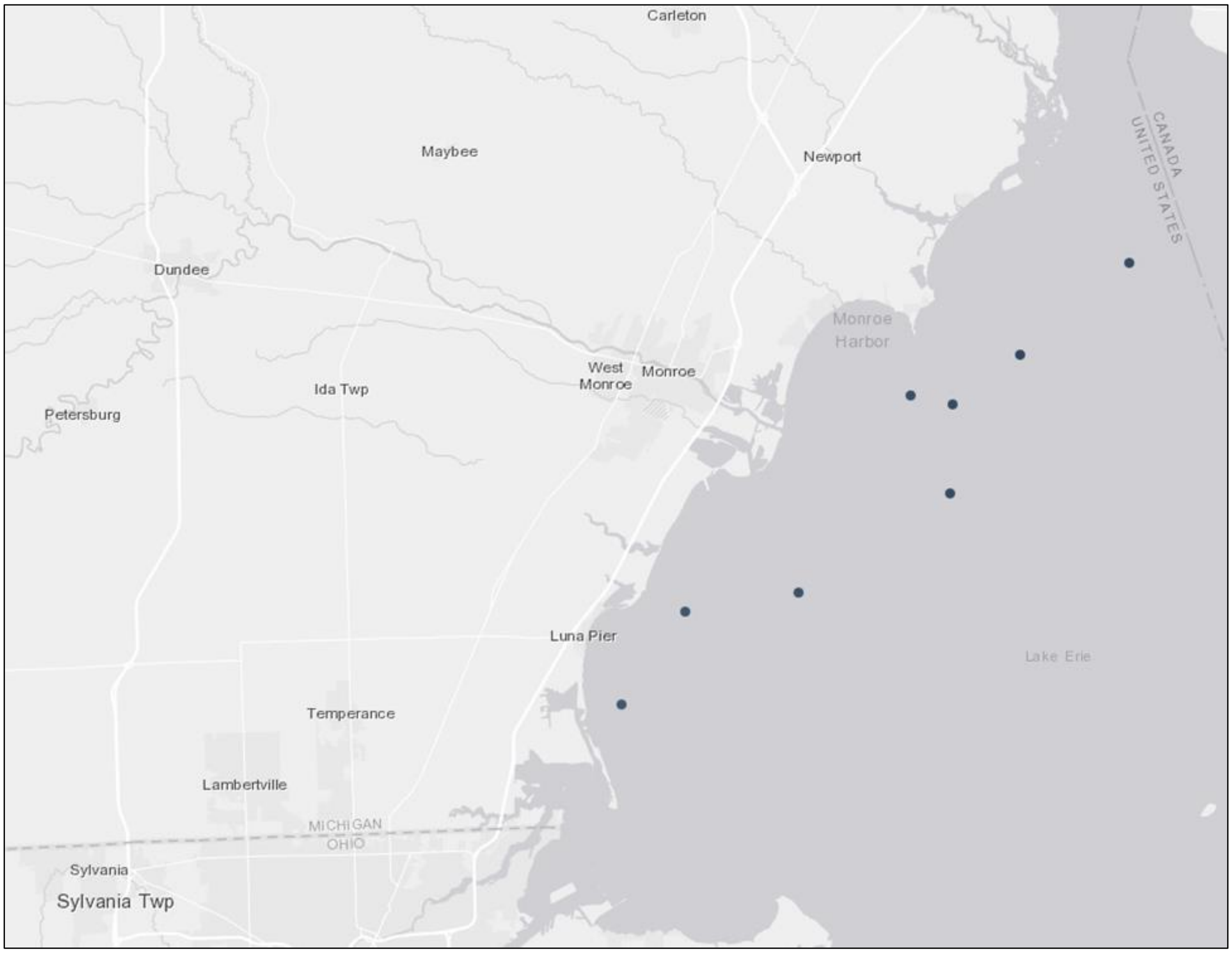


Figure 2.4.7: Location of 2019 trawling sites in Michigan waters of Lake Erie.

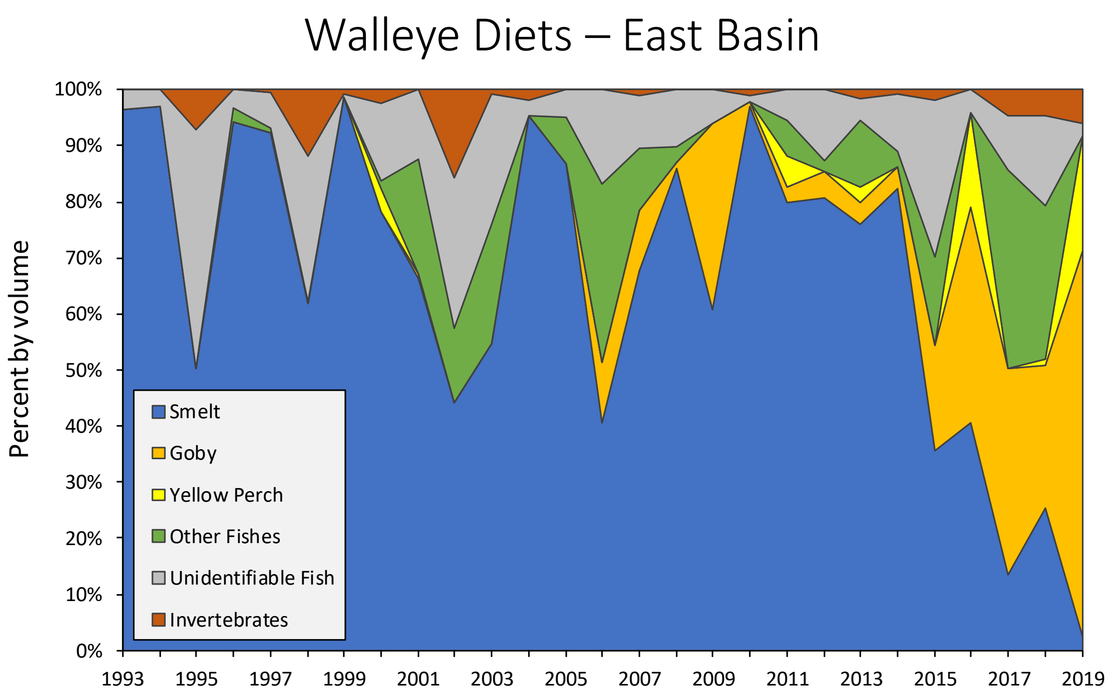


Figure 2.5.1.1: The percent contribution by volumn of identifiable prey in non-empty stomachs of adult Walleye caught by summertime anglers in New York's portion of Lake Erie, 1993-2019.

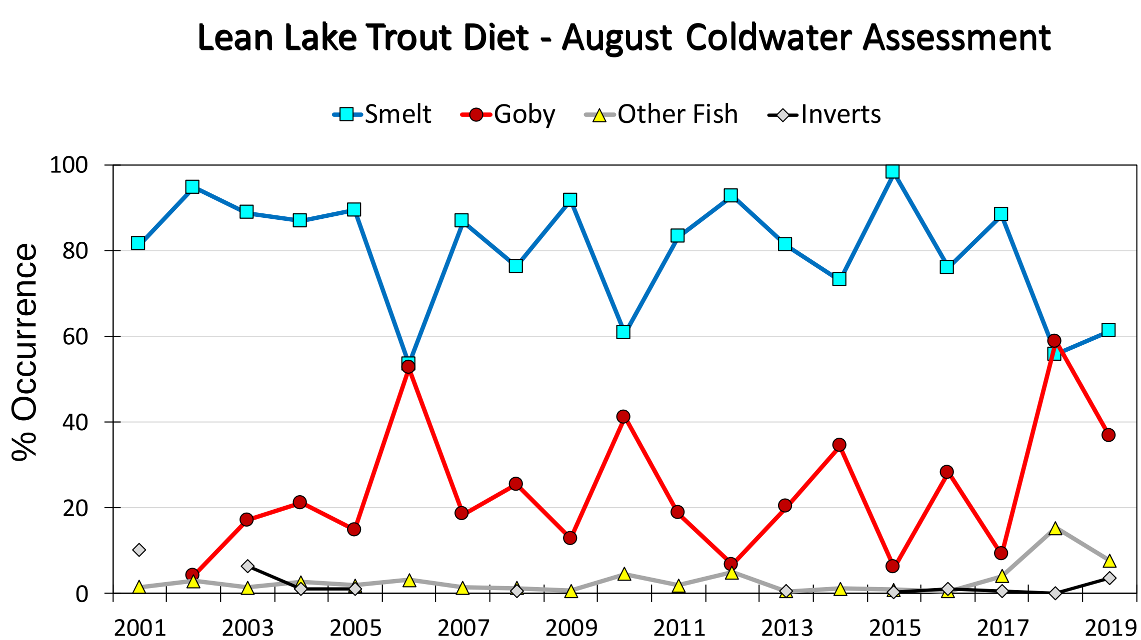


Figure 2.5.1.2: Percent occurrence of diet items from non-empty stomachs of Lean strain Lake Trout collected in eastern basin gill net assessments, August, 2001-2019.

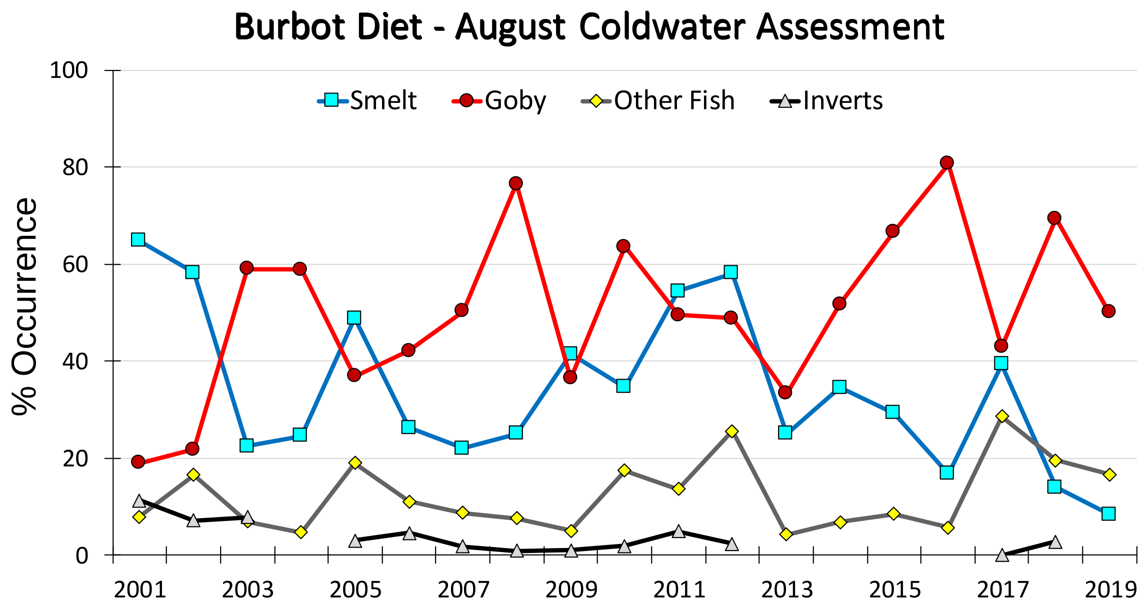


Figure 2.5.1.3: Percent occurrence of diet items from non-empty stomachs of Burbot collected in eastern basin gill net assessments, August, 2001-2019.

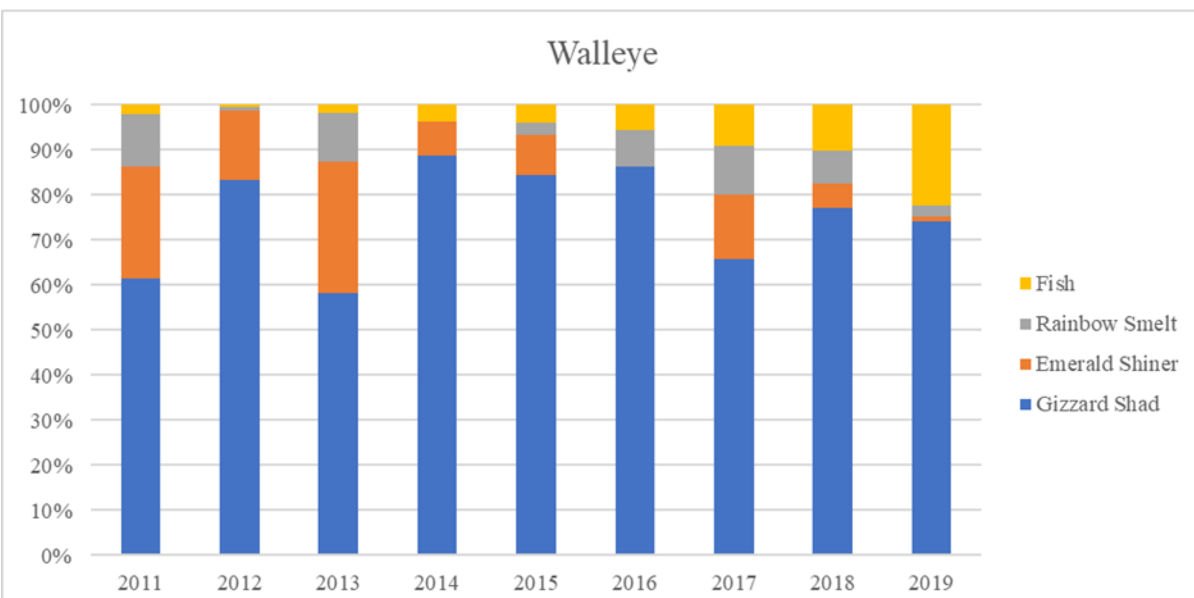


Figure 2.5.2.1: Adult Walleye diet composition (Percent dry weight) from non-empty stomachs collected in gill nets from central basin, Ohio waters of Lake Erie, 2011 - 2019.

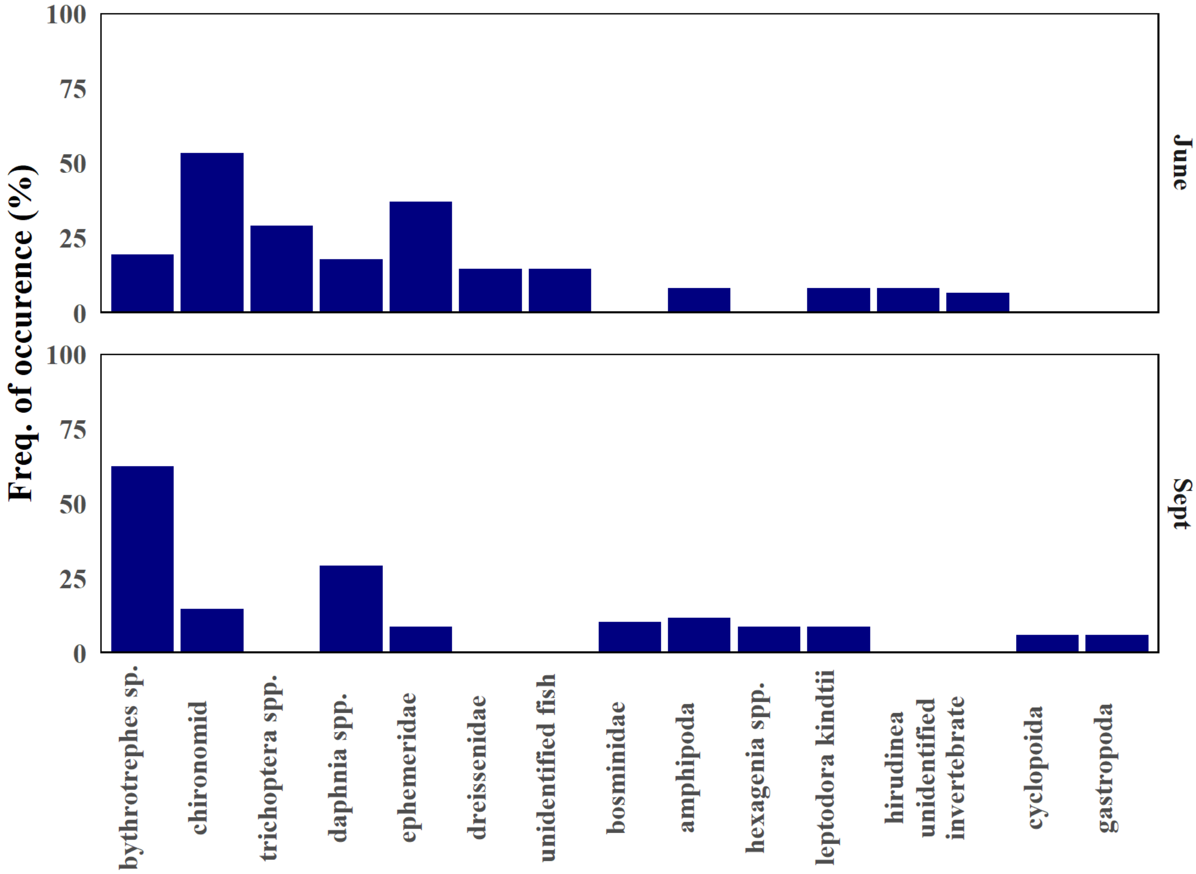


Figure 2.5.3.1: Frequency of occurrence of prey taxa in diets of Yellow Perch from western Lake Erie in June (top) and September 2019 (bottom). Diet items occurring in < 5% of diets are not shown.

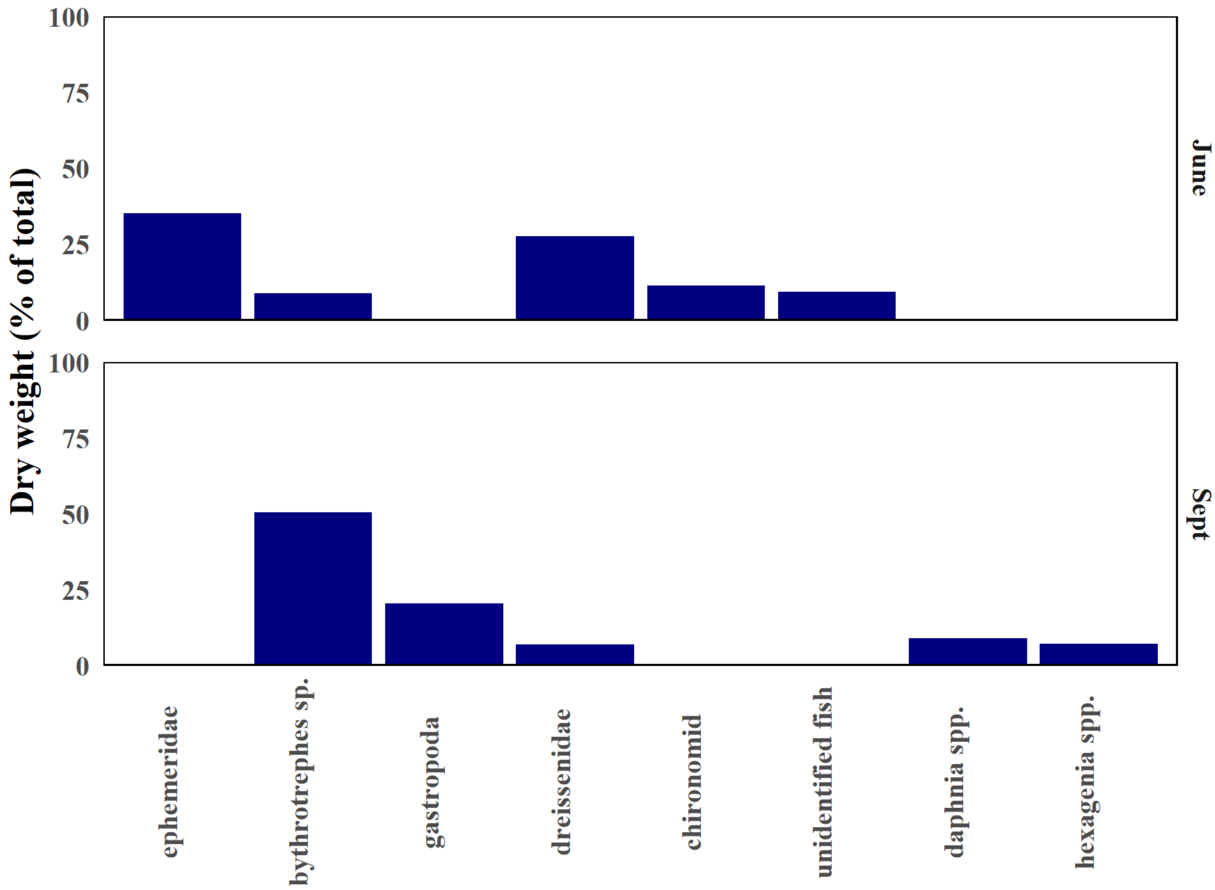


Figure 2.5.3.2: Percent composition of Yellow Perch diets (% dry weight) in western Lake Erie in June (top) and September 2019 (bottom). Diet items totalling < 5% of diet dry weight are not shown.

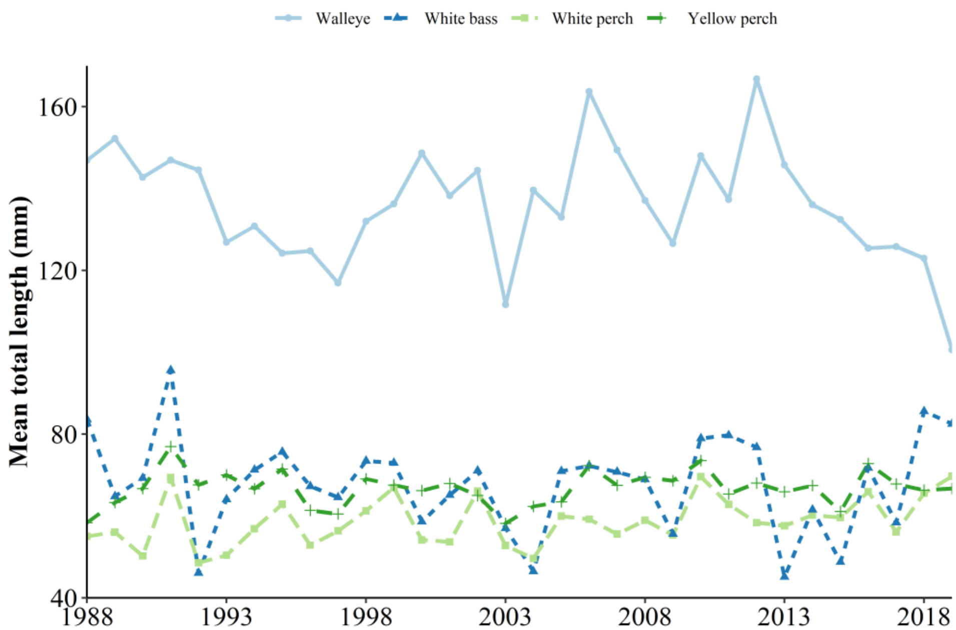


Figure 2.5.3.3: Mean total length of select age-0 fishes in western Lake Erie, August 1987- 2019. Age-0 Walleye are on a seven-year decline.

Charge 3: Continue hydroacoustic assessment of the pelagic forage fish community in Lake Erie, incorporating new methods in survey design and analysis, while following the Great Lake Fishery Commission's Great Lakes Hydroacoustic Standard Operating Procedures where possible/feasible.

3.1 Eastern Basin Hydroacoustic Survey (J. Holden)

A fisheries hydroacoustic survey has been conducted in the East Basin since 1993 to provide estimates of the distribution and abundance of Rainbow Smelt. The current hydroacoustic data acquisition system consists of a Simrad EY60 surface unit with a 120 kHz 7-degree split-beam general purpose transducer mounted on a fixed pole in a down facing orientation approximately 1 m below the water surface on the OMNRF research vessel, R/V *Erie Explorer.* The 2014 edition of this report details the history, design and analytical methods of the hydroacoustic survey (Forage Task Group 2014). Prior to 2007, companion mid-water trawls have been completed by NYSDEC and found that age-1+ Rainbow Smelt made up greater than 95% of catches of fish of their acoustic target strength in meta-hypolimnion trawls. In the absence of companion trawls post 2007, the acoustic data were analyzed with the assumption that all meta-hypolimnion targets above the minimum target strength threshold were age-1+ Rainbow Smelt. In 2019, OMNRF extended the survey window to incorporate mid-water trawling to test the assumption that the meta-hypolimnion targets were still likely to be age-1+ Rainbow Smelt. A midwater trawl 13.6 m long with a 7.1 m headline, spread with 0.5 m^2 aluminum doors was fished throughout the water column in areas where high densities of acoustic targets were identified. Net depth was set through a combination of warp adjustment, surface float line length and foot rope weight (see Emmrich et al. 2010 for gear configuration). Depth and temperature loggers were attached to the head and foot lines to record fishing depth, temperature and vertical opening.

Results

A complete survey of all 10 acoustic transects and 24 mid-water tows distributed throughout the basin was conducted in 2019. Mid-water trawl catches confirmed the assumption that the majority of targets meeting the minimum target strength threshold in the hypo-metalimnion layer are age-1+ Rainbow Smelt. In total, 588 (2,917 g) age-1+ Rainbow Smelt were caught in hypo-metalimnion tows numerically compromising 40% of the total catch but representing 94% of the biomass. The remainder of the catch was limited to age-0 Rainbow Smelt (percent of total N = 44%, percent of total biomass = 3%) and age-0 Yellow Perch (percent of total N = 15%, percent of total biomass = 2%). The epilimnetic tows were composed of 99% age-0 species (81% YOY Rainbow Smelt, 18% YOY Yellow Perch); thus, it is possible that catches of age-0 in the meta-hypolimnion tows are a result of net contamination as the net passed through the upper layer.

The area weighted basin-wide age-1+ Rainbow Smelt density was 180 fish/ha (range = 0-4578 fish/ha, median = 51 fish/ha). This is the lowest density observed through the time series (Fig. 3.1.1). While considerably lower than past years, the highest densities were observed in the Long Point area (Fig. 3.1.2).

3.2 Central Basin Hydroacoustic Survey (P. Kočovský, J. Deller)

The Ontario Ministry of Natural Resources (OMNR), Ohio Department of Natural Resources (ODNR), and the U.S. Geological Survey (USGS) have collaborated to conduct joint hydroacoustic and midwater trawl surveys in the central basin of Lake Erie since 2004. The 2019 central basin hydroacoustic survey was planned according to the protocol and sample design established at the 2003 hydroacoustic workshop (Forage Task Group 2005). The survey design calls for eight cross-basin transects on which both hydroacoustic and trawl data are collected. Beginning in 2008, all hydroacoustic data were collected and analyzed following recommendations in the Standard Operating Procedures for Fisheries Acoustics Surveys in the Great Lakes (GLSOP; Parker-Stetter et al. 2009). The primary purpose of the central basin hydroacoustic survey is to estimate densities of Rainbow Smelt and Emerald Shiner, which are the primary pelagic forage species in the central basin.

Hydroacoustics

Hydroacoustic data were collected from the USGS R/V *Muskie* and the ODNR-DOW R/V *Grandon*. Acoustic transects corresponding to Loran-C TD lines were sampled from one half hour after sunset (approximately 2130) to no later than one half hour before sunrise (approximately 0530), depending on the length of the transect and vessel speed. The prescribed starting and ending points for the survey are the 10 m depth contour lines.

Hydroacoustic data, from both vessels, were collected with BioSonics DTX® echosounders and BioSonics Visual Acquisition (release 6.0) software. Data from the R/V *Muskie* were collected using a 120 kHz, 7.4-degree, split-beam transducer mounted inside a through-hull transducer tube at a depth of 1.5 m below the water surface. Data from the R/V *Grandon* were collected with a 122 kHz, 7.6-degree, split-beam transducer mounted to the starboard hull on a movable bracket, roughly equidistant between the bow and stern, with the transducer 1.3 meters below the surface.

Sound was transmitted at four pulses per second with each pulse lasting 0.4 milliseconds. Global Positioning Systems (GPS) coordinates from the R/V *Muskie* were collected using a Garmin ® GPSMAP 76Cx, and from the R/V *Grandon* with a Garmin 17HVS. Both vessels interfaced GPS coordinates with the echosounders to obtain simultaneous latitude and longitude coordinates. Temperature readings from just above the thermocline were used to calculate speed of sound in water because the largest proportion of fish occurred nearest this depth in the water column. Selecting the temperature nearest the thermocline, where fish were densest, results in the least cumulative error in depth of fish targets. Prior to data collection, a standard tungsten-carbide calibration sphere, specific to 120-kHz transducers, was used to calculate a calibration offset for calculating target strengths. Background noise was estimated by integrating beneath the first bottom echo at several locations for each transect, then averaging within a transect. The average noise within a transect was subtracted from total backscatter.

Analysis of hydroacoustic data was conducted following guidelines established in the Standard Operating Procedures for Fisheries Acoustics Surveys in the Great Lakes (Parker-Stetter et al. 2009) using Echoview ® version 10 software. Proportionate area backscattering coefficient was scaled by mean target strength (TS) calculated from *in-situ* single targets identified using Single Target Detection Method 2 (Parker-Stetter et al. 2009) to generate density estimates for distance intervals. Distance intervals for each transect were 500 m. Settings for pulse length determination level, minimum and maximum normalized pulse length, maximum beam compensation, and maximum standard deviation of major and minor axes followed Parker-Stetter et al. (2009). Minimum target strength threshold was -74 dB. This value permitted inclusion of all targets at least -68 dB within the half-power (6 dB) beam angle. We used -68 dB as the lowest target of interest based on distribution of *in-situ* target strength and theoretical values for Rainbow Smelt of the lengths captured in midwater trawls (Horppila et al. 1996, Rudstam et al. 2003). The Nv statistic, a measure of the probability of observing more than one fish within the sampling volume (Sawada et al. 1993), which will result in overlapping echoes, was calculated for each interval-by-depth-stratum cell (hereafter cell) to monitor the quality of *in-situ* single target data. If Nv for a cell was greater than 0.1, the mean TS of the entire stratum within a transect where Nv values were less than 0.1 was used (Rudstam et al. 2009).

Density estimates for fish species and age groups were calculated by multiplying acoustic density estimates within each cell by proportions calculated from trawls. For each cell we used proportions of each species and age group from the trawl sample nearest the cell.

Trawling

The R/V *Keenosay* conducted up to nine 20-minute trawls on transects in Ontario waters concurrent with and on the same transect as the R/V *Muskie* acoustic data collection. Whenever possible, trawl effort was distributed above and below the thermocline to adequately assess species composition throughout the water column. The catch was sorted by species and age group, and relative proportions of each species and age group were calculated for each trawl. Age group was determined based on age-length keys and length distributions. Age group classifications consisted of young-of-the-year (age-0) for all species, yearling-and-older (age-1+) for forage species, and age-2-and-older (age 2+) for predator species. Total lengths were measured from a subsample of individuals from each species and age group. Temperature and dissolved oxygen profiles were recorded at each trawl location.

Results

Six cross-lake transects were sampled between 8 July and 12 July 2019 with hydroacoustics. The two remaining transects were not completed due to weather and vessel commitments to other projects. All four transects were sampled with midwater trawls by the R/V *Keenosay* (Figure 3.2.1). No trawl samples were collected in US waters.

Thirty-five midwater trawls were completed. Young-of-the-year Rainbow Smelt were caught in every trawl and were the majority of the catch in 24 of the 35 trawls completed in 2019. Yearling-and-older Rainbow Smelt (age-1+) comprised a very small proportion of the midwater trawl catch in 2019 and were the majority of the catch in only 2 trawls on transect 57600 (Table 3.2.1). Young-of-the-year Rainbow Smelt were more evenly distributed across the basin compared to age-1+ Rainbow Smelt. Young-of-the-year Yellow Perch were caught on all transects and in almost every trawl in 2019 (Table 3.2.1). Yellow Perch comprised the majority of the catch in six trawls. Other species were encountered on the western transects (57600 and 57350) and were the largest proportion of the catch in three trawls. Other species caught in midwater trawls included Freshwater Drum (age-1+), Gizzard Shad (age-0), Logperch (age-1+), Moronidae spp. (age-0), Mudpuppy, Walleye (age-0 and age-2), White Bass (age-0 and age-2), White Perch (age-2), Yellow Perch (age-2; Table 3.2.1). Young-of-the-year Gizzard Shad accounted for most of the other species captured in 2019 and were encountered on the western most transect, 57350.

Acoustic TS distributions did not show differences in TS across depth strata in 2019. Highest acoustic densities of smaller targets (age-0 Rainbow Smelt) were found throughout the water column on all transects. Larger targets (age-1+ Rainbow Smelt) were found below the thermocline, but their densities were low and masked by the smaller targets. Hence, it was not possible to separate targets by depth. Because there was no objective justification for partitioning into layers, we analyzed and report whole water column results (Table 3.2.2).

Spatial distribution across transects varied by species and age group. Young-of-the-year Yellow Perch tended to be evenly distributed from north to south on the western transects. Densities on the eastern transects were noticeably higher in the north relative to the south (Figure 3.2.2). Young-of-the-year Rainbow Smelt were evenly distributed throughout the basin, with densities being slightly higher in the east relative to the west (Figure 3.2.3). Yearling-and-older Rainbow Smelt densities were low throughout the basin (Figure 3.2.4). The highest densities were located close to shore and west of Erieau.

Density estimates for Emerald Shiner have been generally declining since 2011, and they have been caught in very low numbers in trawls since 2015 (Figure 3.2.5). Only ten Emerald Shiners were caught in 2019 from nearshore sites on the western transects (57600 and 57350; Figure 3.2.1). This was the second lowest catch of Emerald Shiners in since 2004. Young-of-the-year Rainbow Smelt increased to the second highest density in the time series (Figure 3.2.5). Yearling-and-older Rainbow Smelt densities remain very low and were similar to densities in 2017 (Figure 3.2.5).

Temperature and dissolved oxygen profiles collected concurrently with midwater trawls found one area of low oxygen near the south end of 57455, near Cleveland. At this location, dissolved oxygen levels dropped below 3 mg/L, a concentration which is known to influence fish behavior (Vanderploeg 2009). Based on target distributions from whole-transect echograms, the thermocline depth was uniform across most transects (Figure 3.2.6). The north end of 58100 displayed a slight upwelling event on the night of sampling. Temperature and dissolved oxygen profiles collected by the R/V *Keenosay* and during the acoustic survey support the thermocline patterns on the echograms.

Discussion

In all surveys between 2005 and 2018, there was an observable change in TS with depth near the thermocline typically associated with the separation of age-0 and age-1+ Rainbow Smelt. Initial post-processing of 2019 hydroacoustic data following the GLSOP (Parker-Stetter et al. 2009) resulted in no discernible shift in TS with depth. This was corroborated by results of trawling; age-0 Rainbow Smelt, the most abundant species and age group captured in trawls, were as abundant both in absolute and relative numbers in deeper layers as in shallower layers. The highest catch of age-1+ Rainbow Smelt was in a shallow tow close to shore, which was contrary to past years when the highest catches were in deeper tows further from shore. Young-of-the-year Yellow Perch showed a weak relationship of decreasing proportion of catch as depth increased, but they accounted for only 17% of the trawl catch, whereas age-0 Rainbow Smelt were 56%.

Yearling and-older Rainbow Smelt densities were extremely low and isolated to a small area of the basin. Age-1+ Rainbow Smelt were caught in only 10 midwater trawl samples. Eight of those trawl samples had fewer than 30 individuals per tow. The remaining two trawl samples had 202 and 1,305 age-1+ Rainbow Smelt. The skewed and localized catch of age-1+ Rainbow Smelt is not a function of the trawl survey. In some years, thermocline depths can be sloped along the length of a transect, leaving a large volume of water below the thermocline on one end (>10 m) and a very low volume of water on the other end (< 2 m). When there is very little depth below the thermocline it is difficult to run midwater trawls that can effectively catch age-1+ Rainbow Smelt. This was not the case in 2019. Thermocline depths were fairly level and uniform among the transects and tows were run at or below the thermocline on all transects. When age-1+ Rainbow Smelt were captured, it was typically in trawls run at or below the thermocline.

The acoustic density estimates of age-0 Rainbow Smelt may be biased high in 2019. Our method of estimating densities of species and age groups from acoustic densities is to multiply hydroacoustic fish density (determined using echo integration in each acoustic cell) by the proportion of each major species and age group in the trawl sample nearest to the hydroacoustic cell. In 2019, proportions of age-0 Rainbow Smelt were higher than in previous years owing not to high absolute catches of age-0 Rainbow Smelt but to very low abundance of all other species. Thus, a higher percentage of hydroacoustic density estimates were apportioned to age-0 Rainbow Smelt than all other species and age groups. Overall trawl effort in terms of number of trawl samples and spatial and depth coverage were similar compared to previous years, hence we discount differential effort as causal in observed differences.

3.3 West Basin Hydroacoustic Survey (M. DuFour)

Since 2005, the Ohio Department of Natural Resources Division of Wildlife has conducted a hydroacoustic forage fish survey in the western basin of Lake Erie. This survey consists of three, cross-basin transects surveyed between one-half hour after sunset and one-half hour before sunrise. No trawling has ever been conducted in conjunction with acoustic data collection.

Methods

Three cross basin transects were successfully sampled in 2019. Surveying took place in July 2019 with Transect 1 completed on 8-9 July, Transect 2 on 9-10 July, and Transect 3 on 10-11 July. We deviated from the traditional fixed Transect 3 route due to the presence of anchored fishing gear (i.e., trap nets) in the area, posing a navigational hazard. All transects were surveyed using a single, downward-facing, 6.3-degree, 201-kHz split-beam transducer, a Garmin global positioning system, and a Panasonic CF-30 laptop computer.

The acoustic system was calibrated prior to the survey with a tungsten carbide reference sphere of known acoustic size. The mobile survey, conducted aboard the ODNR's *RV Almar*, was initiated approximately 0.5 h after sunset and completed by 0.5 h prior to sunrise. Transects were navigated with waypoints programmed in a Lowrance GPS, and speed was maintained at 8-9 km/h. The transducer was mounted to a BioSonics towfish at 1 m below the surface starboard side of the boat. Data were collected using BioSonics Visual Acquisition 6 software. Collection settings during the survey were 10 pings/second, a pulse length of 0.2 msec, and a minimum collection threshold of -70 dB. The sampling environment (water temperature) was set at the temperature 2 m deep on the evening of sampling. Data were written to file and named by the date and time the file was collected. Files were automatically collected every 30 minutes. Latitude and longitude coordinates were written to the file as the data were collected to identify sample location.

Data were analyzed using the Myriax software Echoview 10.0 using a modified process developed by the Ohio Division of Wildlife Inland Fisheries Research Unit. Total length (mm) range was estimated using Love's dorsal aspect equation (Love 1971):

$$TL = 10^{([TS + 26.1]/19.1) * 1000}$$

Biomass (kg) estimates were based on average target length as determined by the above equation and an established length(TL)-weight(Wt) relationship.

$$Wt = (0.0000263*TL^{2.7875})/1000$$

Results

In 2019, three cross-basin transects (approximately 100 km in total) were surveyed July 08-11. Average forage fish densities were highest along Transect 3 (9,687 fish/ha), with the highest concentrations along the southern portion of the transect. Average densities were lowest along Transect 1 (5,385 fish/ha), but variable with high concentrations on the southern and northern edges of the transects (Figure 3.3.1). Average western basin forage fish densities (8,335 fish/ha) were slightly higher than 2018 densities (6,435 fish/ha), but below the time series average (14,298 fish/ha). Biomass (16.2 kg/ha) was higher than 2018 (11.4 kg/ha), and similar to the long-term mean (16.5 kg/ha; Figure 3.3.2).

3.4 Hydroacoustic Survey Redesign – Central and West Basins (Z. Slagle, J. Deller, R. Dillon, M. DuFour, and P. Kočovský)

Summary of Existing Surveys

The primary purpose of the central and western basin hydroacoustic surveys is to estimate densities of important forage fishes, primarily Rainbow Smelt and Emerald Shiner in the Central Basin and Gizzard Shad and Emerald Shiner in the West Basin. Surveys take place within five days of the new moon in July to synchronize across the lake.

The central basin hydroacoustics survey has been conducted by OMNR, ODNR, and USGS since 2004. The survey design targets eight cross-basin transects a year, a total of 351 nmi; midwater trawl samples are taken for each transect, usually six trawls per transect. These trawls allow hydroacoustics targets to be apportioned by species. Thus, the survey estimates relative density and biomass for each species. Vessel limitations require four to five days of good weather (waves < 1.0 m). Given the survey length and short temporal window, the complete eight-transect survey has only been completed once between 2004 – 2019.

The west basin hydroacoustics survey began a year later (2005) than that of the central basin and is conducted solely by ODNR. While midwater trawls were originally planned, none have been accomplished to date; therefore, the west basin survey cannot apportion by species and only generates a combined estimate of relative forage density and biomass. The survey design calls for three cross-basin transects a year, totaling 75 nmi. Due to vessel limitations, the complete survey requires three days of good weather (waves < 0.4 m and wind direction parallel to transect direction). Given these strict requirements, the complete survey has been accomplished in only 8 of 13 years, with no midwater trawls accomplished.

In addition to these challenges, sampling strata (e.g., water depth, distance from shore, river plumes) have never been analyzed for either survey (central or west basin). Cross-basin transects were chosen to provide a basin-wide estimate of forage fish abundance in the absence of prior data on species composition and relative distributions. To date, there has been no rigorous assessment of midwater trawl data to assess the current design. The long transects also cause vessels to sample in a large portion of the open lake, placing stringent weather requirements on an already short sampling window.

Survey Redesign

In 2019, hydroacoustics experts in the central and west basins began a discussion about redesigning the hydroacoustics surveys in those basins. Goals defined in these discussions were to: (1) better define the study objectives, especially the target species; and (2) evaluate the sampling intensity of the existing surveys. A reallocation of effort and extent of surveys could alleviate challenges in the existing survey and allow for a more focused survey that provides the appropriate data to managers.

These same experts began reviewing existing hydroacoustics and trawl data in early 2020. Research interests include: (1) degree of variability of forage density among transects; (2) degree of stratification among species and age classes of forage fishes; and (3) number of midwater trawls required to accurately estimate species composition. At the 2020 Pre-LEC meeting, the Lake Erie Committee recommended continued evaluation of the existing survey. The central and west basin hydroacoustics surveys are thus currently under evaluation and survey changes may be implemented as soon as the July 2020 survey.

Table 3.2.1: Percent composition of fish captured in trawl samples collected by the R/V *Keenosay,* in the central basin Lake Erie in July 2019.

Transect	Trawl ID	Depth	Latitude	Longitude	Yellow Perch Age-0	Rainbow Smelt Age-0	Rainbow Smelt Age-1+	Other species[1] all ages
58100	1001	5	42.6245	-81.007	51.7%	48.3%	0.0%	0.0%
58100	1003	5	42.533	-80.973	78.4%	21.6%	0.0%	0.0%
58100	1006	5	42.3808	-80.9177	22.8%	77.2%	0.0%	0.0%
58100	1007	8	42.3625	-80.913	14.4%	85.6%	0.0%	0.0%
58100	1004	9	42.5258	-80.9648	17.6%	82.2%	0.0%	0.1%
58100	1002	10	42.605	-81.0002	31.7%	67.6%	0.4%	0.3%
58100	1005	10	42.5393	-80.9747	8.1%	91.2%	0.0%	0.7%
58100	1008	15	42.3748	-80.9183	6.7%	93.3%	0.0%	0.0%
58100	1009	17	42.3585	-80.9137	0.0%	100.0%	0.0%	0.0%
57850	2001	6	42.5568	-81.4675	23.9%	74.8%	0.0%	1.3%
57850	2003	7	42.4823	-81.4345	14.0%	86.0%	0.0%	0.0%
57850	2006	7	42.3375	-81.3752	25.3%	73.5%	0.0%	1.2%
57850	2002	9	42.5377	-81.4578	27.8%	47.2%	13.9%	11.1%
57850	2004	9	42.4513	-81.4262	2.9%	94.5%	2.4%	0.2%
57850	2007	11	42.3118	-81.3715	10.1%	89.9%	0.0%	0.0%
57850	2005	12	42.4272	-81.4142	3.3%	84.2%	12.0%	0.4%
57850	2008	13	42.2927	-81.3738	1.2%	98.8%	0.0%	0.0%
57850	2009	19	42.3165	-81.3802	6.2%	78.5%	15.4%	0.0%
57600	3001	5	42.066	-81.7487	11.0%	86.3%	0.0%	2.7%
57600	3008	6	42.2595	-81.8277	40.7%	35.6%	0.0%	23.7%
57600	3005	7	42.2102	-81.8065	49.6%	47.8%	0.0%	2.7%
57600	3009	9	42.247	-81.836	1.6%	1.6%	94.7%	2.1%
57600	3002	10	42.0872	-81.7535	1.6%	98.4%	0.0%	0.0%
57600	3003	13	42.1385	-81.7345	1.5%	96.5%	1.0%	1.0%
57600	3006	13	42.2252	-81.8128	68.7%	28.4%	0.0%	3.0%
57600	3004	19	42.0853	-81.747	1.7%	97.0%	1.3%	0.0%
57600	3007	19	42.2105	-81.8133	3.7%	0.9%	93.1%	2.3%
57350	4001	6	41.9328	-82.1623	38.9%	44.4%	0.0%	16.7%
57350	4004	8	42.0627	-82.2235	18.5%	11.1%	0.0%	70.4%
57350	4007	8	42.1302	-82.2518	16.4%	4.4%	0.0%	79.3%
57350	4002	10	41.9195	-82.164	18.5%	63.0%	0.0%	18.5%
57350	4008	12	42.1453	-82.2597	28.9%	33.6%	0.0%	37.6%
57350	4003	13	41.9308	-82.1667	12.6%	75.7%	0.0%	11.7%
57350	4005	13	42.0435	-82.2242	28.6%	65.7%	0.0%	5.7%
57350	4006	15	42.0572	-82.2217	53.1%	34.4%	4.7%	7.8%

1 Other species (N captured): Emerald Shiner (10), Freshwater Drum age-1+ (29), Gizzard Shad age-0 (228), Logperch age-1+ (1), Moronidae spp. age-0 (4), Mudpuppy (87), Walleye age-2 (19), Walleye age-0 (44), White Bass age-2 (2), White Bass age-0 (59), White Perch age-2 (8), Yellow Perch age-2 (4).

Table 3.2.2: Density (number per hectare) of key species by age class for hydroacoustic transects in central basin Lake Erie, July 2019. Transect numbers refer to Loran-TD lines. Species were applied from midwater trawl catch by nearest distance.

Age	Species	57475	57600	57725	57850	57975	58100
Age-0	Rainbow Smelt	4355	12076	13105	17432	18355	26293
Age-1+	Rainbow Smelt	1305	229	67	275	127	3
Age-0	Yellow Perch	575	1780	1826	1113	1184	1983
	All others[1]	166	347	814	67	43	13

1 Other species (N captured): Emerald Shiner (10), Freshwater Drum age-1+ (29), Gizzard Shad age-0 (228), Logperch age-1+ (1), Moronidae spp. age-0 (4), Mudpuppy (87), Walleye age-2 (19), Walleye age-0 (44), White Bass age-2 (2), White Bass age-0 (59), White Perch age-2 (8), Yellow Perch age-2 (4).

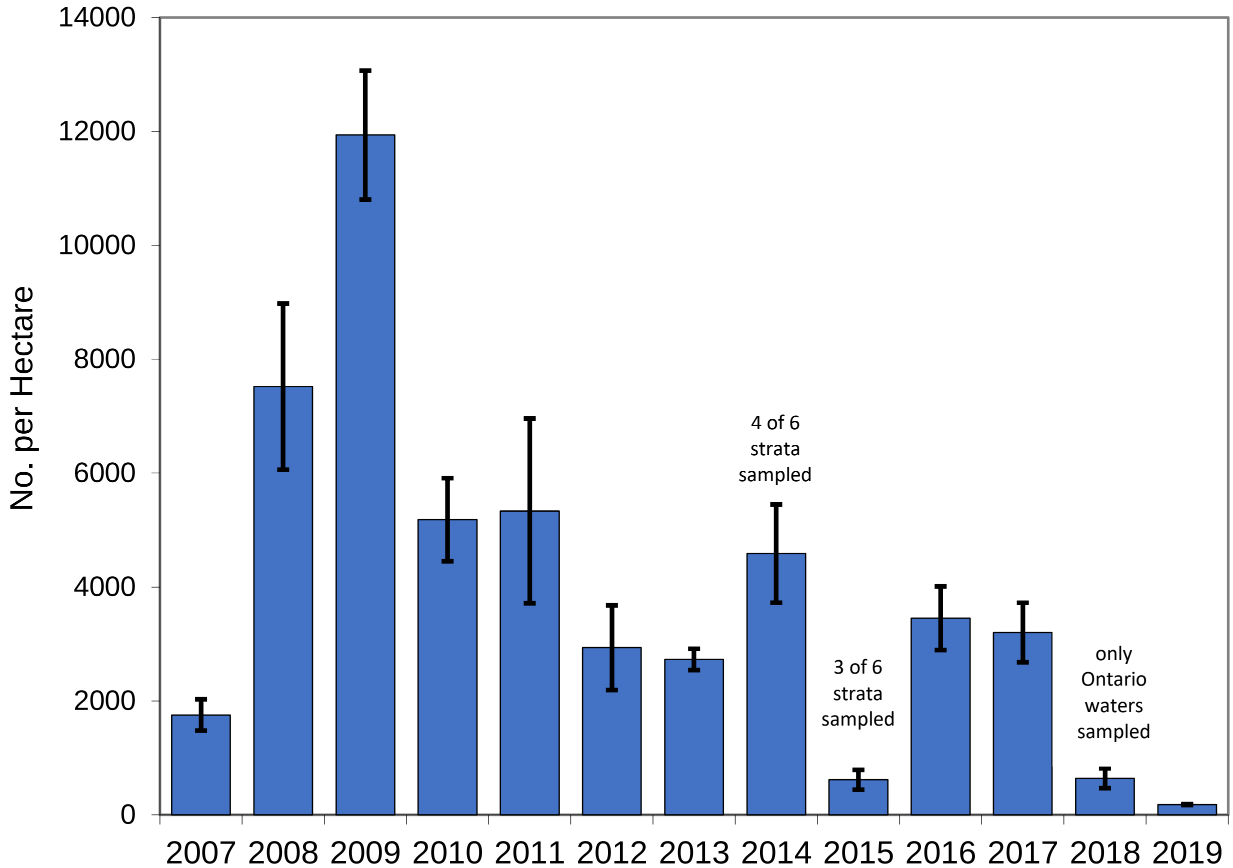


Figure 3.1.1: Mean density (fish per hectare) estimates of age-1+ Rainbow Smelt in coldwater habitat during the July east basin hydroacoustics survey, 2007-2019. Only four strata were sampled in 2014 and three in 2015. Only Ontario waters were sampled in 2018. Error bars represent standard error.

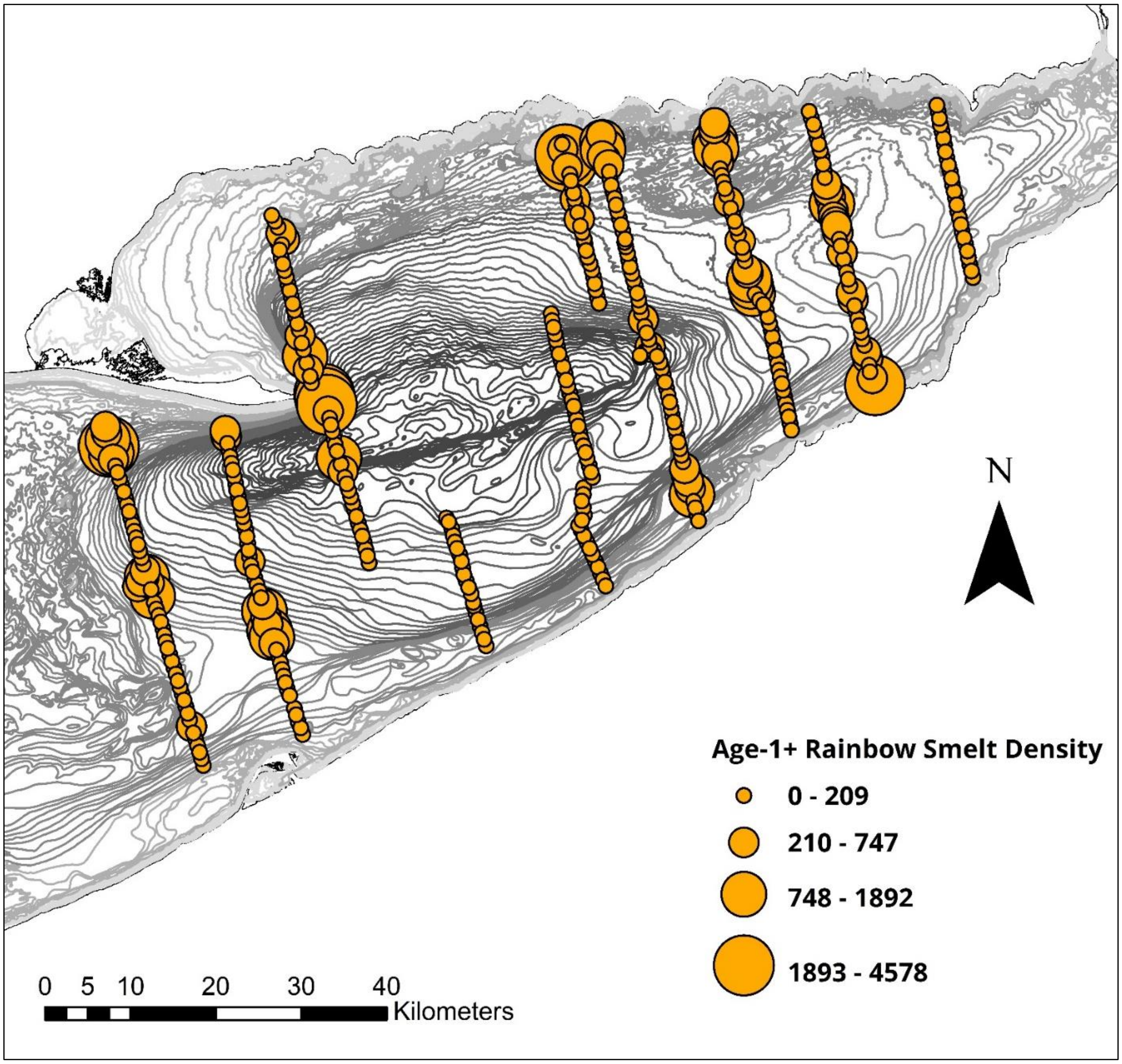


Figure 3.1.2: Age-1+ Rainbow Smelt density (fish per hectare) along hydroacoustic transects in the eastern basin, Lake Erie, in 2019. Contour lines indicate basin depth, with darker shades indicating deeper waters.

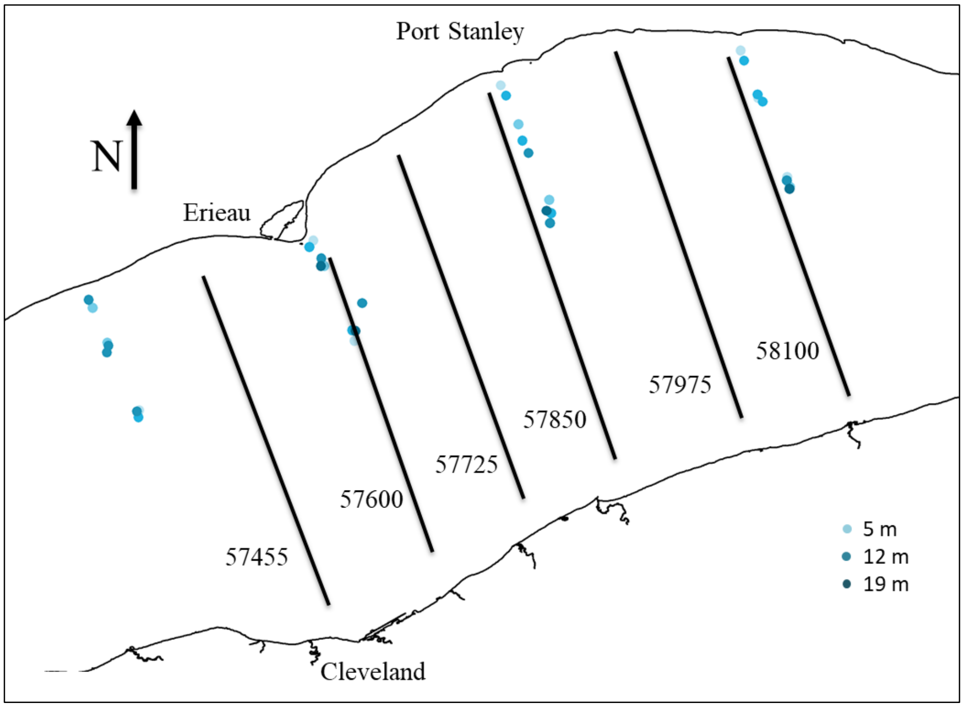


Figure 3.2.1: Hydroacoustic transects (solid lines) and midwater trawling stations in the central basin, Lake Erie, July 17-21, 2019. Transect numbers are Loran-TD lines.

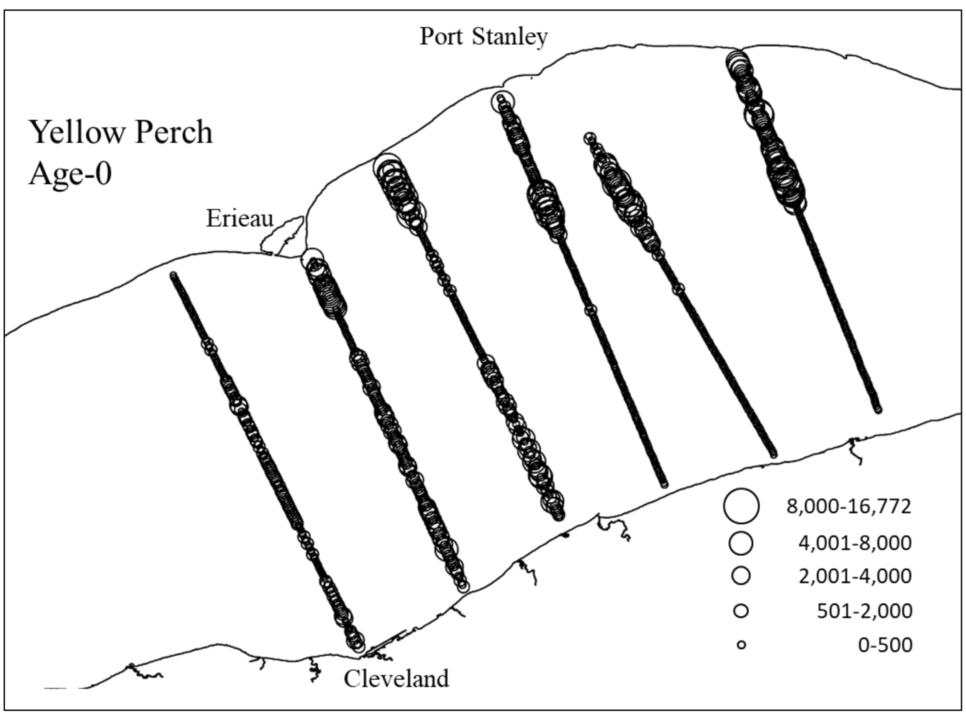


Figure 3.2.2: Density estimates of age-0 Yellow Perch (number per hectare) per distance interval along hydroacoustic transects in the central basin, Lake Erie. Distance intervals were 500 m segments to ensure adequate numbers of single targets for *in-situ* analysis. Transects are Loran-TD lines sampled in 2019.

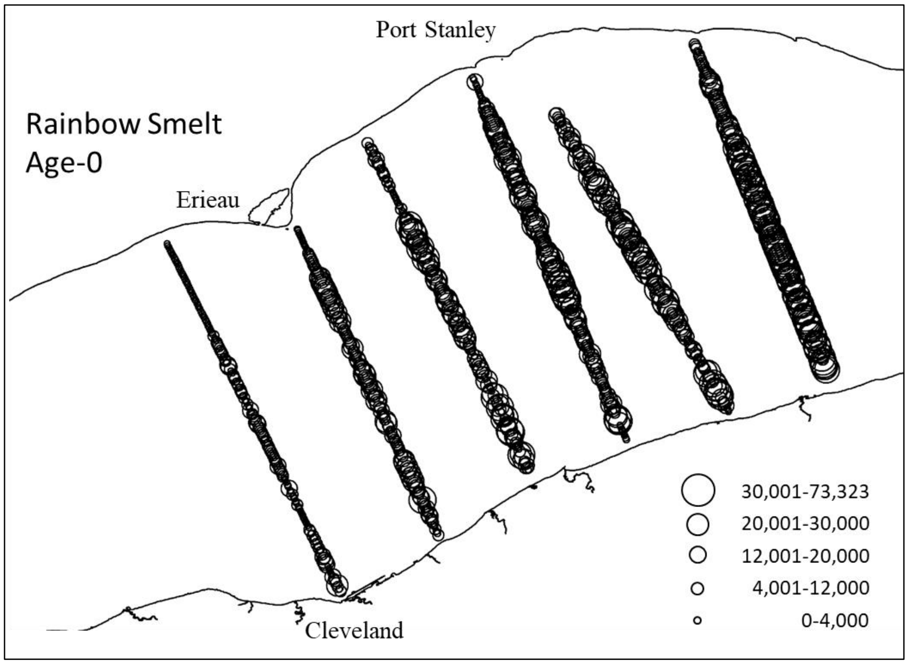


Figure 3.2.3: Density estimates of age-0 Rainbow Smelt (number per hectare) per distance interval along hydroacoustic transects in the central basin, Lake Erie. Distance intervals were 500 m segments to ensure adequate numbers of single targets for *in-situ* analysis. Transects are Loran-TD lines sampled in 2019.

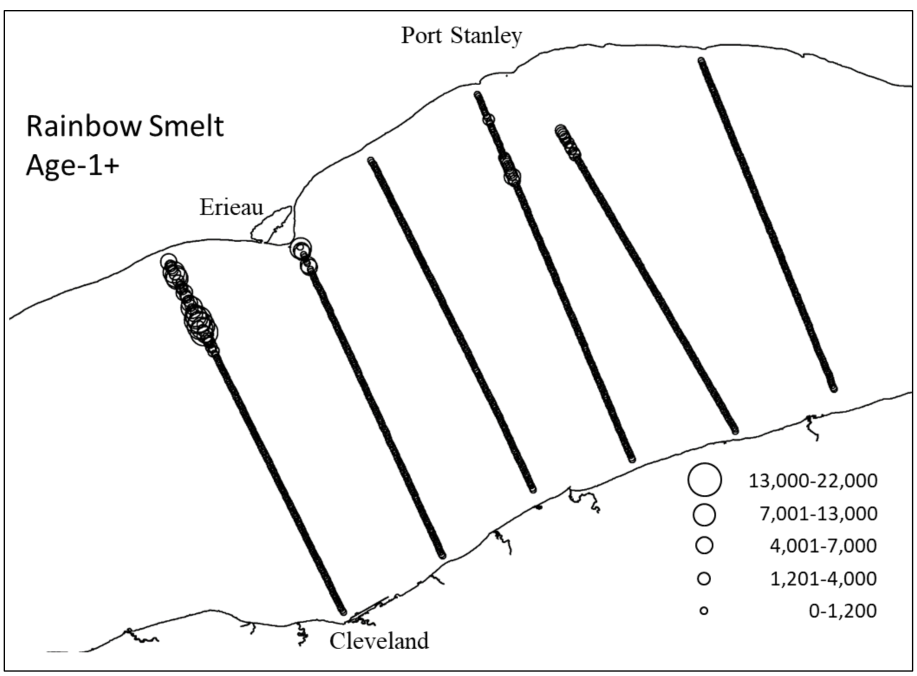


Figure 3.2.4: Density estimates of age-1+ Rainbow Smelt (number per hectare) per distance interval along hydroacoustic transects in the central basin, Lake Erie. Distance intervals were 500 m segments to ensure adequate numbers of single targets for *in-situ* analysis. Transects are Loran-TD lines sampled in 2019.

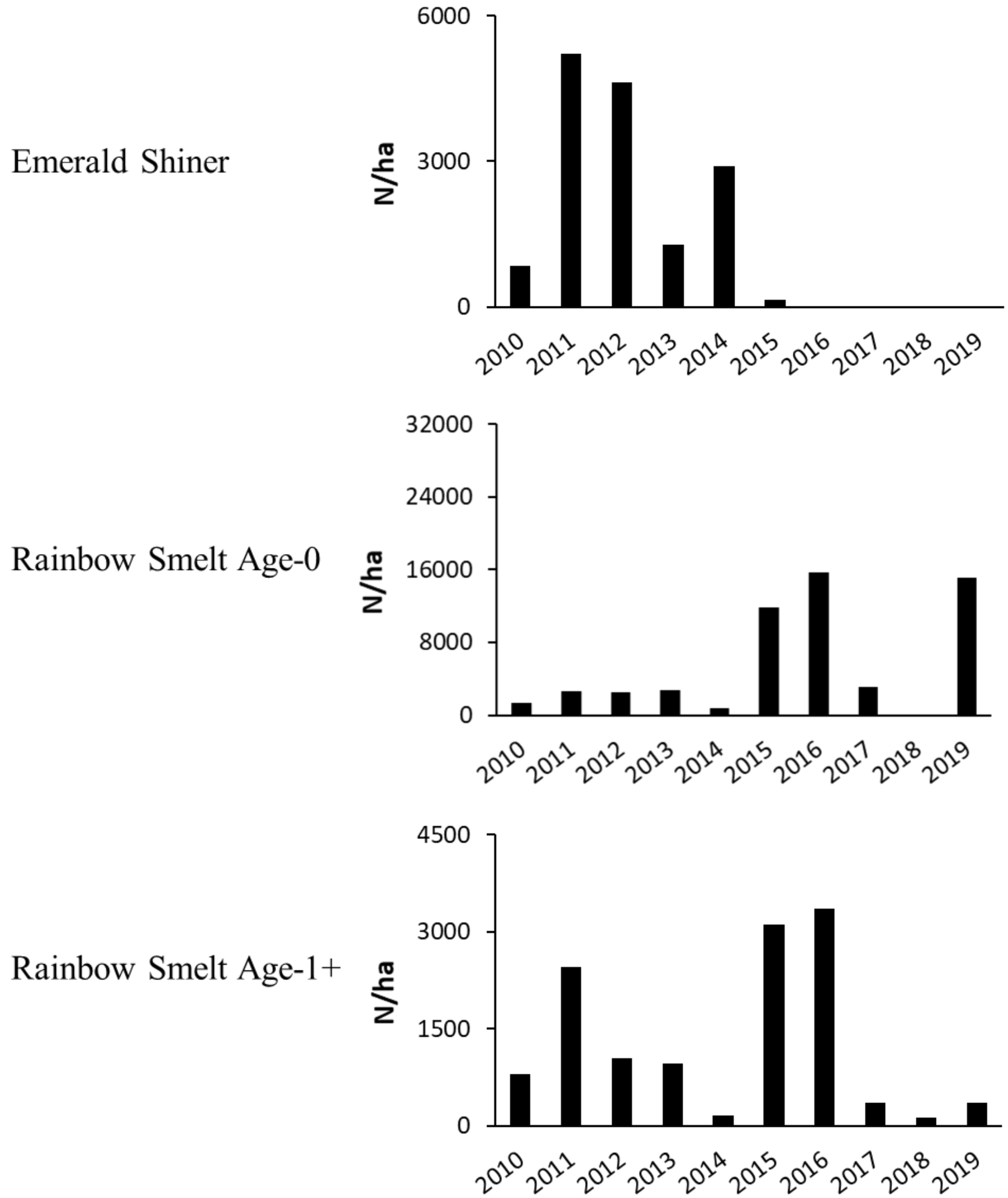


Figure 3.2.5: Mean hydroacoustic density (number per hectare) estimates of pelagic forage fish during the July central basin, Lake Erie hydroacoustic survey, 2010-2019.

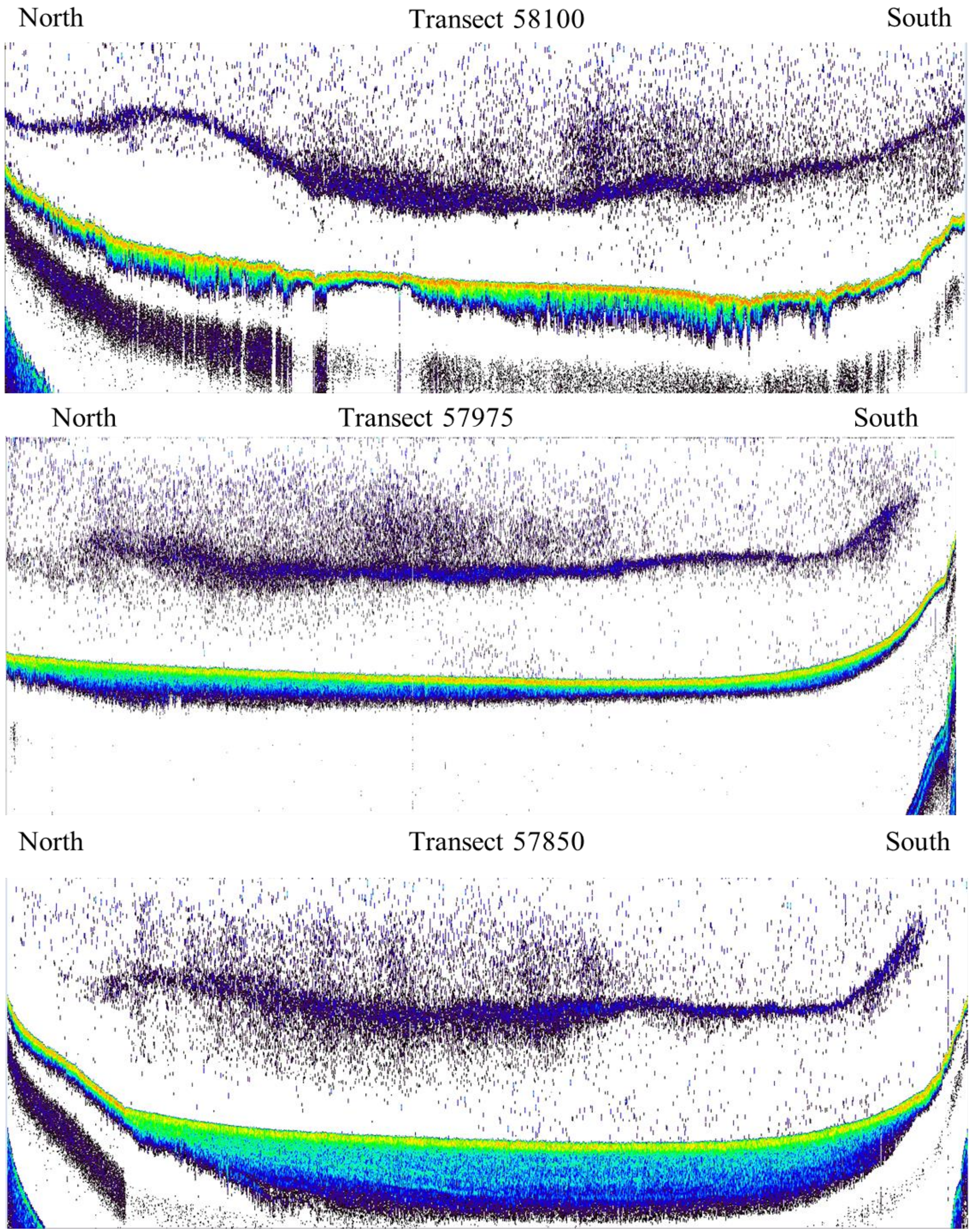


Figure 3.2.6: Echogram files generated from Echoview® software version 6.1 that show total back scattering (Sv) along transects run by the R/V *Muskie* and R/V *Grandon* in the central basin, 2019. Transects are shown from east to west.

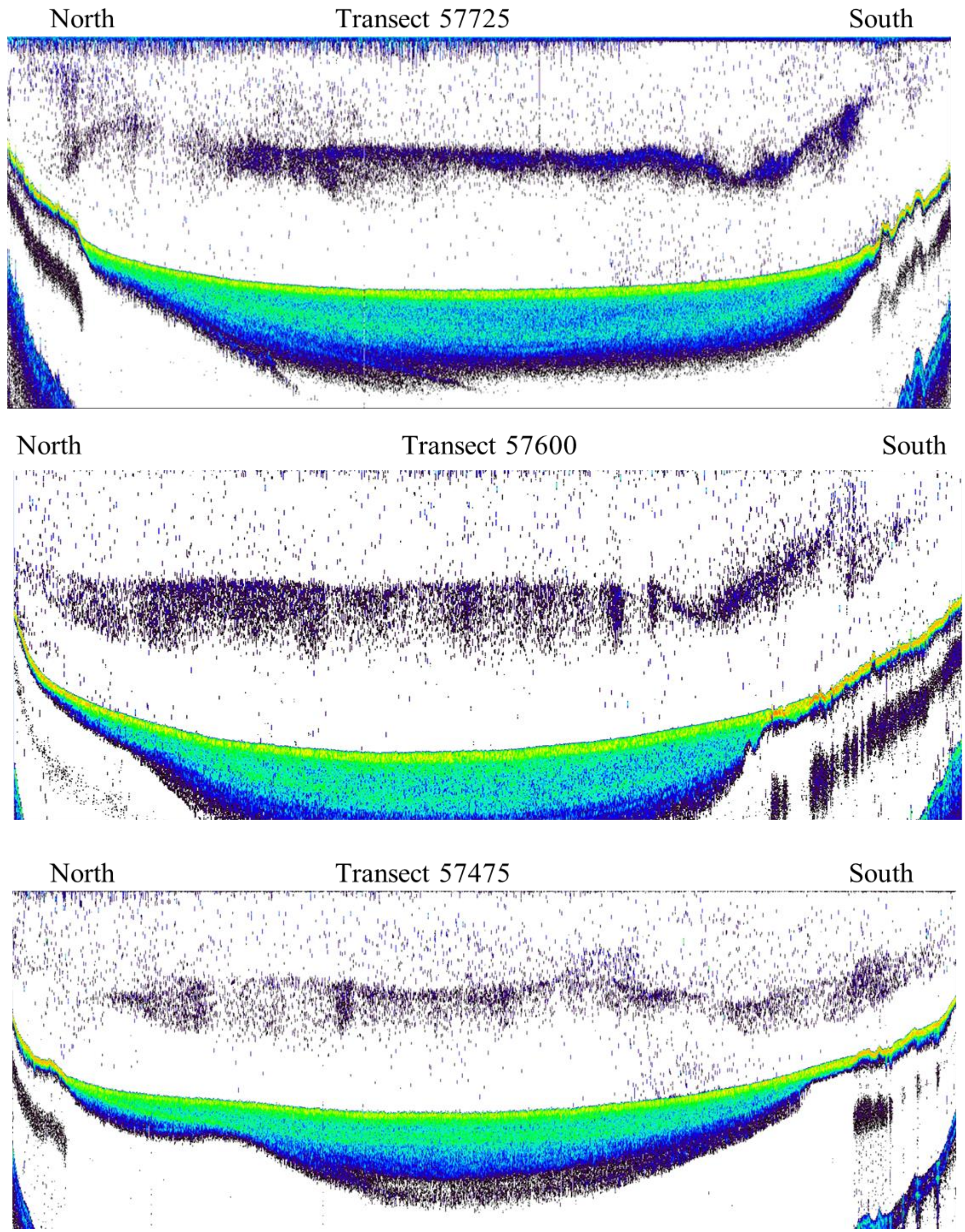


Figure 3.2.6: (Continued) Echogram files generated from Echoview® software version 6.1 that show total back scattering (Sv) along transects run by the R/V *Muskie* and R/V *Grandon* in the central basin, 2019. Transects are shown from east to west.

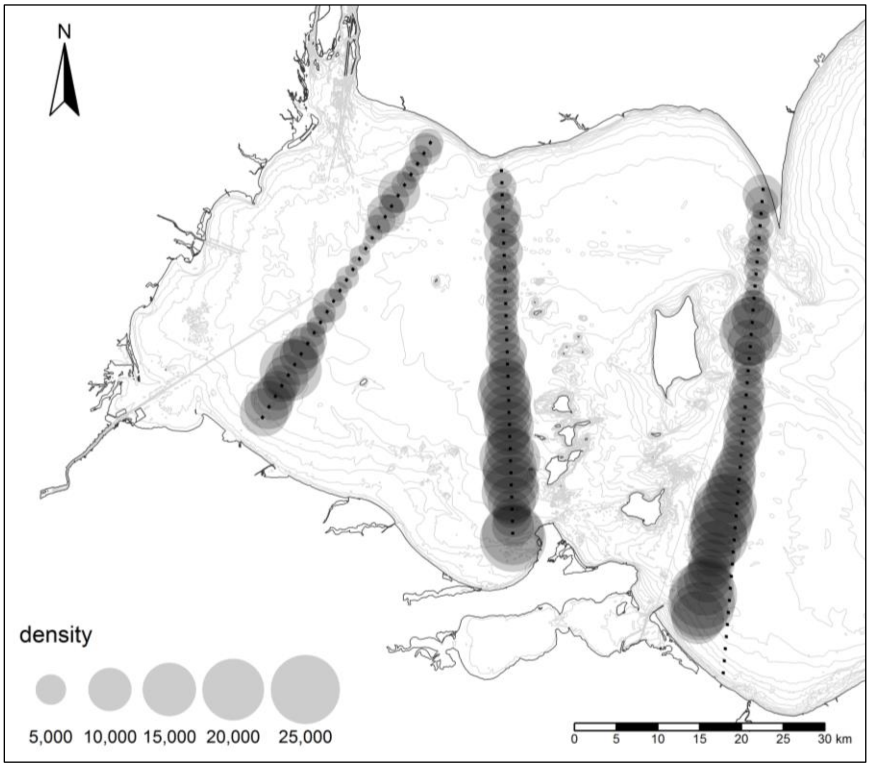


Figure 3.3.1: Acoustic survey transects and associated density (number per hectare) for the western basin of Lake Erie, 2019. Transect 3 deviates off the typical transect due to commercial fishing gear in the transect.

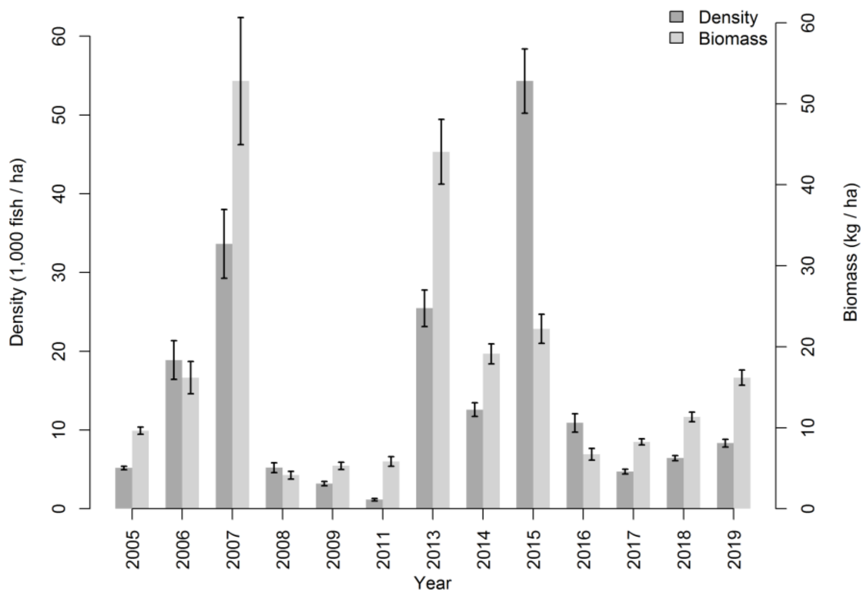


Figure 3.3.2: Average density (fish/ha) and biomass (kg/ha) from the 2019 Lake Erie western basin hydroacoustic survey. Error bars represent ± one standard deviation.

Charge 4: Act as a point of contact for any new/novel invasive aquatic species.

(P. Kočovský)

Since 2016, the Forage Task Group (FTG) has maintained a database to track Aquatic Invasive Species (AIS) in Lake Erie. The FTG adopted the USFWS service list of injurious freshwater species (https://www.fws.gov/injuriouswildlife/11-freshwater-species.html) as the primary species to track. All of those species are believed to be presently absent from Canadian and US waters with the exception of Prussian Carp, which are abundant and spreading in rivers in southern Alberta (Elgin et al. 2014, Docherty 2016). Species not on that list, but of interest to Lake Erie agencies, include Bighead Carp, Silver Carp, Black Carp, Grass Carp, and Rudd. Efforts toward detecting Bighead Carp, Silver Carp, and Black Carp are included in a separate Forage Task Group summary on these species. Grass Carp is present and reproducing in at least two tributaries (Embke et al. 2016). Grass Carp management is conducted through a multi-agency working group, and a joint multi-jurisdictional database is managed and distributed as part of that process. Because Grass Carp is not a new species, and because the status of the Grass Carp population is reported elsewhere, we no longer report on Grass Carp captures. Rudd have reproducing populations in Ontario and New York waters connected to Lake Erie. *There were no new invasive species* captured in Lake Erie or its connected waterways in 2019.

A non-native fish species not on the USFWS list of injurious species but of potential concern in the Great Lakes is Tench. The first record of Tench in the Great Lakes-St. Lawrence system was in the Richelieu River in 1991 (Avlijas et al. 2018). The first mature adults were captured in the Richelieu River in 2000. Tench expanded to Lake Champlain by 2002 and to the St. Lawrence River by 2006. As of 2016, Tench range extended from Quebec City to Lake Saint Francis (~320 river km) along the St. Lawrence and to the southern end of Lake Champlain (~235 river km; see figures in Avlijas et al. 2018). Numbers of Tench captured by commercial fishermen in Lake Saint Pierre has increase rapidly since 2008 (Avlijas et al. 2018). In 2018, a commercial fisherman captured a mature female Tench in Lake Ontario in the Bay of Quinte near Belleville, ON (S. Avlijas, McGill University, personal communication), approximately 90 km from the outlet of Lake Ontario to the St. Lawrence. The rapid expansion suggests there is an elevated risk of Tench entering Lake Erie should their expansion into Lake Ontario continue.

Protocol for Use of Forage Task Group Data and Reports

- The Forage Task Group (FTG) has standardized methods, equipment, and protocols as much as possible; however, data are not identical across agencies, management units, or basins. The data are based on surveys that have limitations due to gear, depth, time and weather constraints that vary from year to year. Any results, conclusions, or abundance information must be treated with respect to these limitations. Caution should be exercised by outside researchers not familiar with each agency's collection and analysis methods to avoid misinterpretation.

- The FTG strongly encourages outside researchers to contact and involve the FTG in the use of any specific data contained in this report. Coordination with the FTG can only enhance the final output or publication and benefit all parties involved.

- Any data intended for publication should be reviewed by the FTG and written permission obtained from the agency responsible for the data collection.

Citation:

Forage Task Group. 2020. Report of the Lake Erie Forage Task Group, March 2020. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission, Ann Arbor, Michigan, USA.

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Appendix: List of Species Common and Scientific Names

Common name	Scientific name	Comments
Alewife	*Alosa pseudoharengus*	Invasive species
Bighead Carp	*Hypophthalmichthys nobilis*	Invasive species, not present in Lake Erie
Black Carp	*Mylopharyngodon piceus*	Invasive species, not present in Lake Erie
Bluegill	*Lepomis macrochirus*	
Brook Silverside	*Labidesthes sicculus*	
Channel Catfish	*Ictalurus punctatus*	
Common Carp	*Cyprinus carpio*	Invasive species
Emerald Shiner	*Notropis atherinoides*	
Freshwater Drum	*Aplodinotus grunniens*	
Gizzard Shad	*Dorosoma cepedianum*	
Grass Carp	*Ctenopharangydon idella*	Invasive species
Johnny Darter	*Etheostoma nigrum*	
Logperch	*Percina caprodes*	
Mimic Shiner	*Notropis volucellus*	
Mudpuppy	*Necturus maculosus*	Native salamander
Rainbow Smelt	*Osmerus mordax*	
Rock Bass	*Ambloplites rupestris*	
Round Goby	*Neogobius melanstomus*	Invasive species
Rudd	*Scardinius erythrophthalmus*	Invasive species
Ruffe	*Gymnocephalus cernuus*	Invasive species
Silver Carp	*Hypophthalmichthys molitrix*	Invasive species, not present in Lake Erie
Silver Chub	*Macrhybopsis storeriana*	
Smallmouth Bass	*Micropterus dolomieu*	
Spottail Shiner	*Notropis hudsonius*	
Tench	*Tinca tinca*	Invasive species, not present in Lake Erie
Troutperch	*Percopsis omiscomaycus*	
Tubenose Boby	*Proterorhinus semilunaris*	Invasive species
Walleye	*Sander vitreus*	
White Bass	*Morone chrysops*	
White Perch	*Morone americana*	Invasive species
White Sucker	*Catostomus commersoni*	
Yellow Perch	*Perca flavescens*	