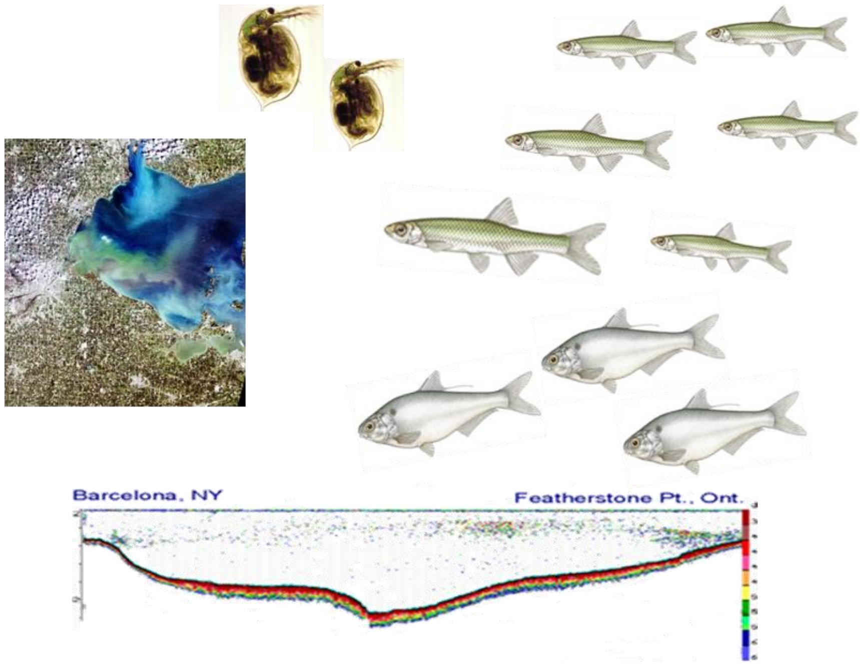
# Report of the Lake Erie Forage Task Group

## March 2019

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| | |
|---|---|
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## Presented to:

**Standing Technical Committee**
**Lake Erie Committee**
**Great Lakes Fishery Commission**

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## Executive Summary

# FORAGE TASK GROUP EXECUTIVE SUMMARY REPORT MARCH 2019

Lake Erie Committee

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

**Introduction**

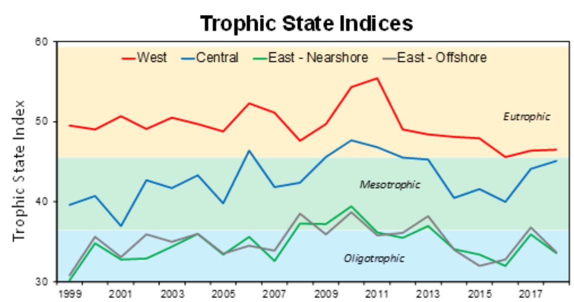
The Lake Erie Committee Forage Task Group report addresses progress made in 2018 on five charges:

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.
3. Continue hydroacoustic assessment of the pelagic forage fish community in Lake Erie, incorporating new methods in survey design and analysis while following the GLFC's Great Lakes Hydroacoustic Standard Operating Procedures where possible/feasible.
4. Report on the use of forage fish and new invasive species in the diets of selected commercially or recreationally important Lake Erie predator fishes.
5. Develop and maintain a database to track new or emerging Aquatic Invasive Species in Lake Erie that exhibit the potential to directly impact economically important fisheries.

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 an LEC, STC, or FTG representative.

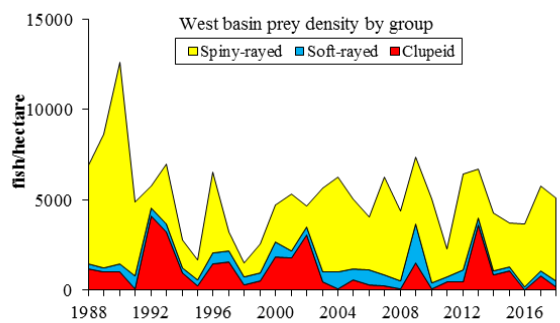
***Interagency Lower Trophic Level Monitoring***

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 Chl *a* measures, indicate that the western basin is slightly above the targeted mesotrophic status, the central basin is within targeted mesotrophic status, which favors percid production, 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.



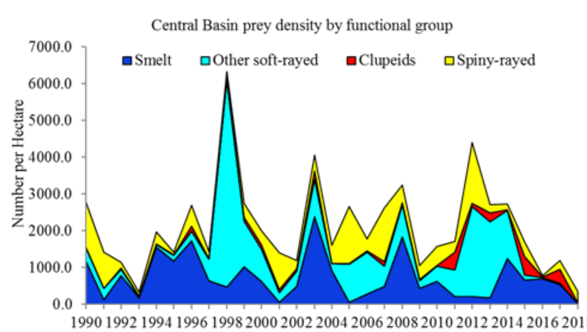

***West Basin Status of Forage***

In 2018, hypolimnetic dissolved oxygen levels were below the 2 mg per liter threshold at three sites during the August trawling survey (all located near the eastern interface with the central basin). In total, data from 71 sites were used in 2018. Total forage abundance declined but was near the ten-year mean. Total forage biomass increased 33%. Age-0 Walleye relative abundance in 2018 was the highest ever recorded in the time series (255/ha), twelve times greater than the ten-year mean (21/ha) and 40% higher than the historic 2003-year class. Young-of-the-year (age-0) Yellow Perch (959/ha) was well above the long-term mean (340/ha). Young-of-the-year Gizzard Shad declined 75% from 2017 and remain highly variable. Young-of-the-year Rainbow Smelt (0.1/ha) and yearling-and-older (age-1+) Rainbow Smelt densities (0.3/ha) returned to minimal levels after high densities in 2017. Age-0 Freshwater Drum and all ages of Troutperch densities were well above ten-year averages. Densities of age-0 and age-1+ Emerald Shiners have increased for two years straight but remain very low (~20% of the ten-year mean). Round Goby abundance was the lowest since the fish was first detected in the west basin (1997).

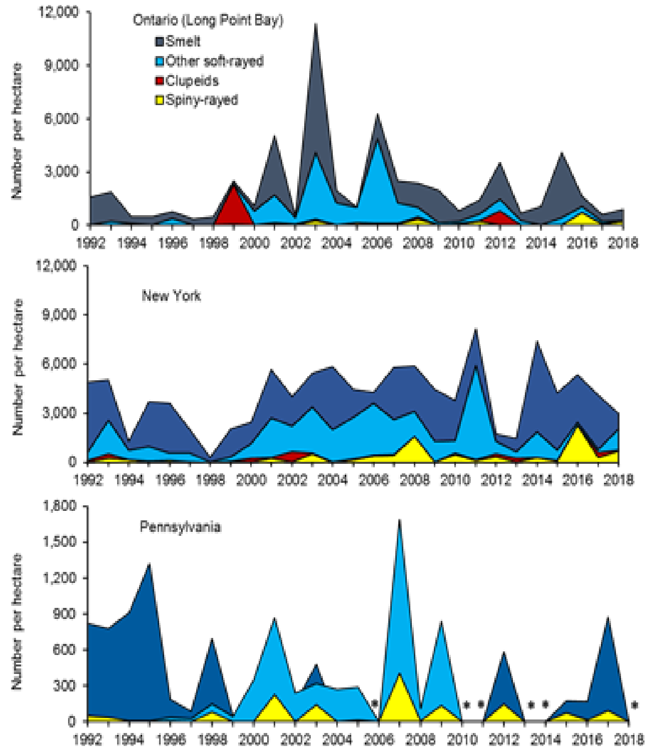



***Central Basin Status of Forage***

Forage abundance in Ohio waters has generally decreased since 2012. In 2018, most forage species continued to decline and are at the lowest densities since 1993. Spiny-rayed species increased slightly from 2017 but remain well below average. Emerald Shiner



indices continue to be well below long-term means throughout the basin. In 2018, indices for the primary forage species, Rainbow Smelt, Emerald Shiner, Round Goby and Gizzard Shad were all well below long-term means in Ohio. Young-of-the-year and age-1+ indices for all species were some of the lowest in the last ten years. In 2018, Yellow Perch age-0 indices in Ohio increased over the last two years and are slightly above long-term means.




***East Basin Status of Forage***

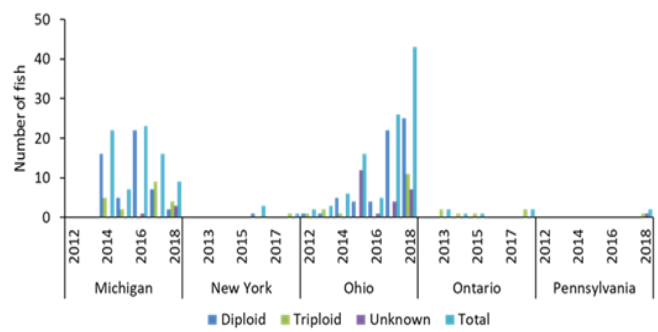
Total forage fish abundance in 2018 increased in Ontario over 2017 but remained well below the long-term mean. Abundance decreased in New York. Pennsylvania did not sample due to vessel constraints. Catches of age-0 and age-1+ Rainbow Smelt were below long-term means in both jurisdictions. Young-of-the-year Emerald Shiner catches were low in both jurisdictions. Yearling-and-older catches were low in Ontario but high in New York, above long-term means. Catches of age-0 Yellow Perch have generally been above long-term means in recent years. 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. Beginning with surveys of the eastern basin in 1993, coverage was expanded to the central basin in 2000 and western basin in 2004. In 2018, the east basin survey was conducted from July 8-11, the central basin survey from July 16-20, and the west basin survey on July 12 and 19. East basin forage fish density was low ($17^{th}$ percentile in the time series), with a mean of 642 forage fish the size of age-1+ Rainbow Smelt per hectare. In the central basin, hydroacoustic densities and midwater trawl catch rates of Rainbow Smelt were some of the lowest in the time series. Emerald Shiner have been generally declining since 2011 and have been in very low abundance in the survey since 2015. In the west basin, average forage fish densities were highest on the middle transect (7,300 fish/ha), while densities peaked at the northern and southern ends of the eastern transect. Average western basin forage fish densities (6,435 fish/ha) were slightly higher than 2017 densities (4,726 fish/ha), but below the time series average (15,143 fish/ha).

***Aquatic Invasive Species***

The Aquatic Invasive Species charge was developed in recognition of the need for a systematic, centralized, lake-wide effort to track records of new, non-native species that might become invasive. In 2018, FTG members reported 3 species on the Injurious Species list or other unusual non-native species. Two Rudd were captured 8 August by electrofishing in Ashtabula Harbor, which is within the known geographic range of Rudd in the Great Lakes. Fifty-seven Grass Carp were captured in Lake Erie or its tributaries in 2018. Forty-three were reported from Ohio, nine in Michigan, two in Pennsylvania, two in Ontario and one in New York. The number of diploid, triploid, and total Grass Carp captured in Lake Erie has increased since recording began in 2012. The increase in 2014 reflects the first year state agencies began targeting capture of Grass Carp. Tubenose Goby has been captured in Ontario and Michigan waters of western Lake Erie every year since 2015. Tubenose Goby captured since 2015 have been in deeper waters and farther south and east since 2011, representing an expansion of known habitats used by this non-native species.



# Charges to the Forage Task Group 2018-2019

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.

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

4. Report on the use of forage fish and new invasive species in the diets of selected commercially or recreationally important Lake Erie predator fish.

5. Develop and maintain a database to track new or emerging Aquatic Invasive Species in Lake Erie that exhibit the potential to directly impact economically important fisheries.

**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)

In 1999, the FTG initiated a Lower Trophic Level Assessment program (LTLA) 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 and 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, we will summarize the last 20 years of data for summer surface temperature, summer bottom dissolved oxygen, chlorophyll *a* concentrations, water transparency and total phosphorus, and zooplankton. Data from all stations were included in the analysis unless noted.

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, 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 the water at 0-1 meter depth 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 1.0.2). A slightly increasing trend in summer surface water temperature is evident for all basins. In 2018, the mean summer surface water temperature was average in the west basin (23.5 °C), below average in the central basin (21.8°C), and above average in the east basin (21.3 °C).

## 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 1.0.3). In 2018, there were no observations from the west basin stations of DO below the 2.0 mg/L threshold.

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 2018, bottom DO was below the 2.0 mg/L threshold in the central basin on three occasions, all at Station 8 (7/5/18 - 1.2 mg/L; 8/12/18 – 0.2 mg/L; 8/29/18 – 0.9 mg/L) (Figure 1.0.3). There were also two other occasions where bottom DO was just above the 2.0 mg/L threshold (Station 10 on 8/1/18 – 2.4 mg/L; Station 11 on 7/31/18 – 2.2 mg/L).

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 1.0.3). In 2018, 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 level. In the west basin, mean chlorophyll *a* concentrations have mainly been above targeted levels in the 20 year time series, fitting into eutrophic status rather than targeted mesotrophic status (Figure 1.0.4). Annual variability is also the highest in the west basin. In 2018, the mean chlorophyll *a* concentration was 6.1 µg/L in the west basin, which was 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, and that trend continued in 2018 (4.4 µg/L) (Figure 1.0.4). In the east basin, chlorophyll *a* concentrations in the nearshore waters have been below the targeted mesotrophic level for the entire time series (Figure 1.0.4). 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 2018, the mean chlorophyll *a* concentrations were 1.7 µg/L in the nearshore waters of the east basin and 1.8 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 1.0.5). In 2018, total phosphorus concentrations in the west basin increased to 35.3 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 have been increasing in recent years (Figure 1.0.5). Total phosphorus measures in the central basin in 2018 were 23.4 µg/L, which was lower than the previous year but still well above targets. 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 1.0.5). 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 and had risen above the targeted oligotrophic range from 2008 through 2013 but have declined in more recent years. In 2018, mean total phosphorus concentrations in the east basin decreased in both the nearshore (7.9 µg/L) and offshore (7.9 µg/L) waters, putting 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, which is below the FCO target, for the entire time series (Figure 1.0.6). Mean summer transparency in the west basin was 2.3 m in 2018, which represents a decline from 2017 measures and within the eutrophic range. 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 1.0.6). In 2018, water transparency decreased to 3.7 m but remained well within the targeted mesotrophic range. In the nearshore water of the east basin, water transparency was in the oligotrophic range, which is above the FCO targets, from 1999 through 2006, sharply declined, and then steadily increased and generally remained within the FCO targets for the next ten years (Figure 1.0.6). Following a one-year decline in 2017, water transparency increased again in 2018 to 6.4 m, which was within the oligotrophic 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, then increased thereafter. In 2018, mean summer transparency was 7.5 m in the offshore waters, which was within the targeted oligotrophic range and the second highest transparency in the time series.

### 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 1.0.7). Median TSI values indicate that the west basin remained in a eutrophic status from the beginning of the time series until 2015, which was more favorable for a centrarchid (bass, sunfish) fish community. 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, Yellow Perch) production. In the central basin, median TSI values have generally remained within the targeted mesotrophic range for the entire time series. Trends in the nearshore waters of the east basin indicate median TSI values and ranges mostly below the targeted mesotrophic range in the early years of the time series, increasing into the targeted mesotrophic zone in the late-2000s, decreasing back into oligotrophic status since 2014. Similar trends are apparent in the offshore waters of the east basin. The TSI values for 2018 indicate borderline meso/eutrophic status in both the west (46.5) and central (45.1) basins, and oligotrophic status in both the nearshore (33.6) and offshore (33.7) waters of the eastern basin (Table 1.0.2). Trends in trophic status measures indicate that Lake Erie is decreasing in productivity but generally remains in a favorable condition for percid production.

### 1.7 Zooplankton Biomass

Mean zooplankton biomass varies among basins and years. In the west basin, the 2018 average biomass was 190.8 mg/m$^3$, which was the third highest value in the time series and well above the long-term mean of 105.9 mg/m$^3$ (Figure 1.0.8). Cladocerans provide the bulk of the biomass of zooplankton in the west basin although increases in both calanoid and cyclopoid copepods have been observed in recent years. In the central basin, the 2018 mean zooplankton biomass was 94.6 mg/m$^3$, which was less than the long-term mean biomass (129.4 mg/m$^3$). Zooplankton biomass in the central basin has been stable over the past five years (Figure 1.0.8). Calanoid copepods have typically been higher in biomass in the central basin compared to the west basin with cladocerans less numerous, but copepod biomass has been conspicuously low for the past five years. In the east basin, overall zooplankton biomass is traditionally lower compared to the central and west basins with cladocerans and calanoid copepods equally important (Figure 1.0.8). Zooplankton biomass in the east basin was the second lowest in the time series in 2018 (21.0 mg.m$^3$) and well below the long-term mean (58.1 mg/L). The low biomass in 2018 was primarily due to an absence of large-bodied daphnia (Cladoceran) and calanoid copepods.

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 1.0.2. Trophic state index and current trophic status, by basin, from Lake Erie, 2018. 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 |

| | 2018 TSI | 2018 Trophic Status |
|---|---|---|
| West | 46.5 | Eutrophic |
| Central | 45.1 | Mesotrophic |
| East - Nearshore | 33.6 | Oligotrophic |
| East - Offshore | 33.7 | Oligotrophic |

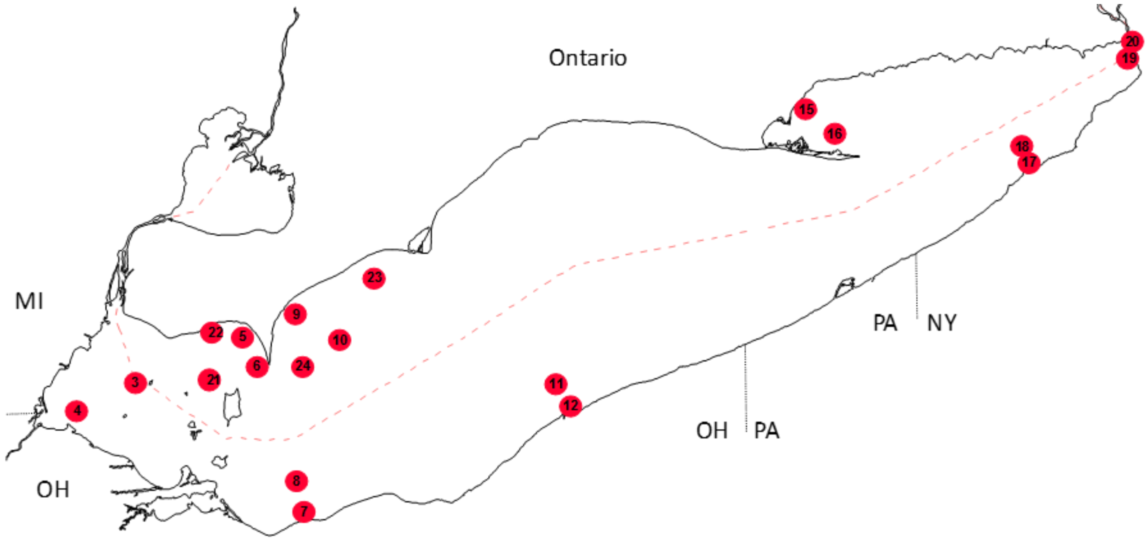



Figure 1.0.1. Lower trophic level sampling stations in Lake Erie sampled in 2018

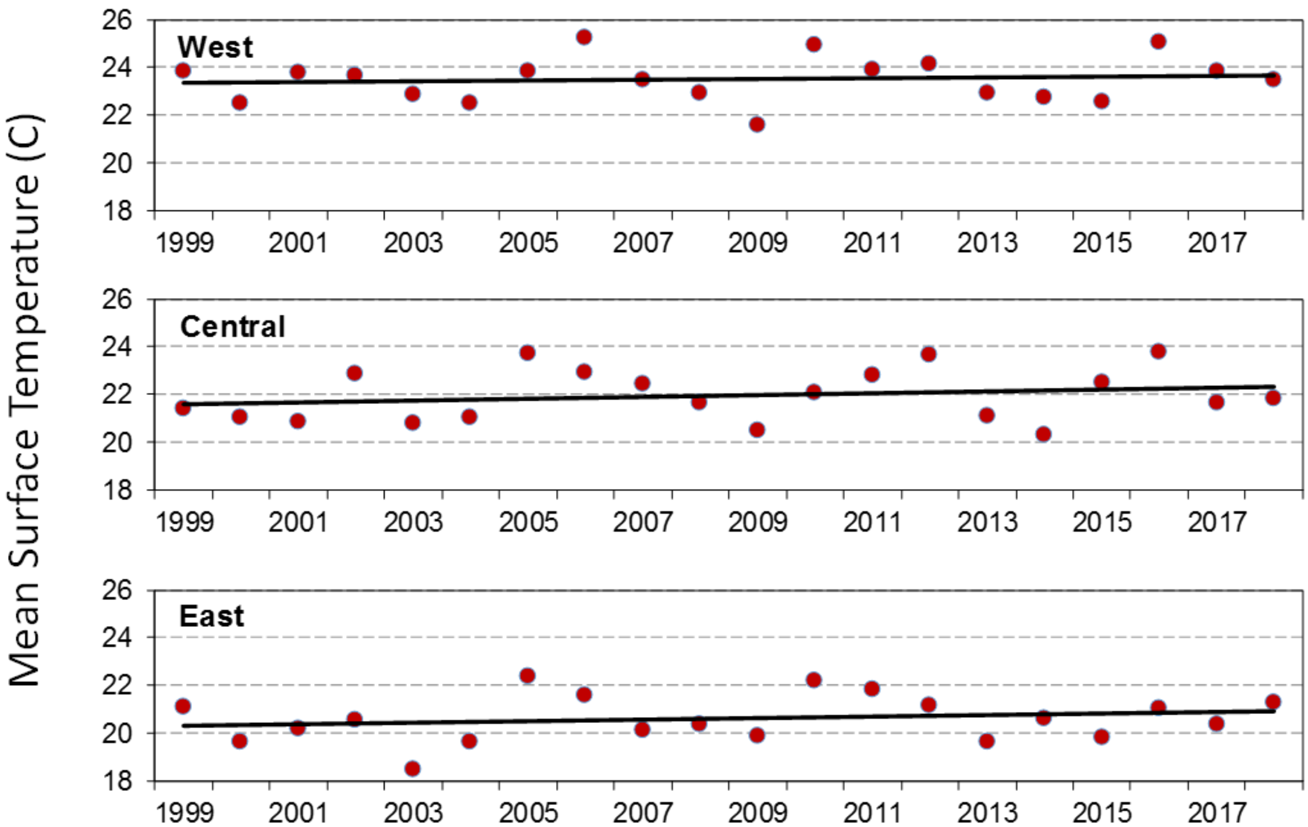



Figure 1.0.2 Mean summer (June-August) surface water temperature (°C) at offshore stations, weighted by month, by basin in Lake Erie, 1999-2018. Solid black lines represent time series trends. Data included in this analysis by basin and station: West – 4, 6, 21; Central – 8, 10, 11, 24; East – 16, 18, 19.

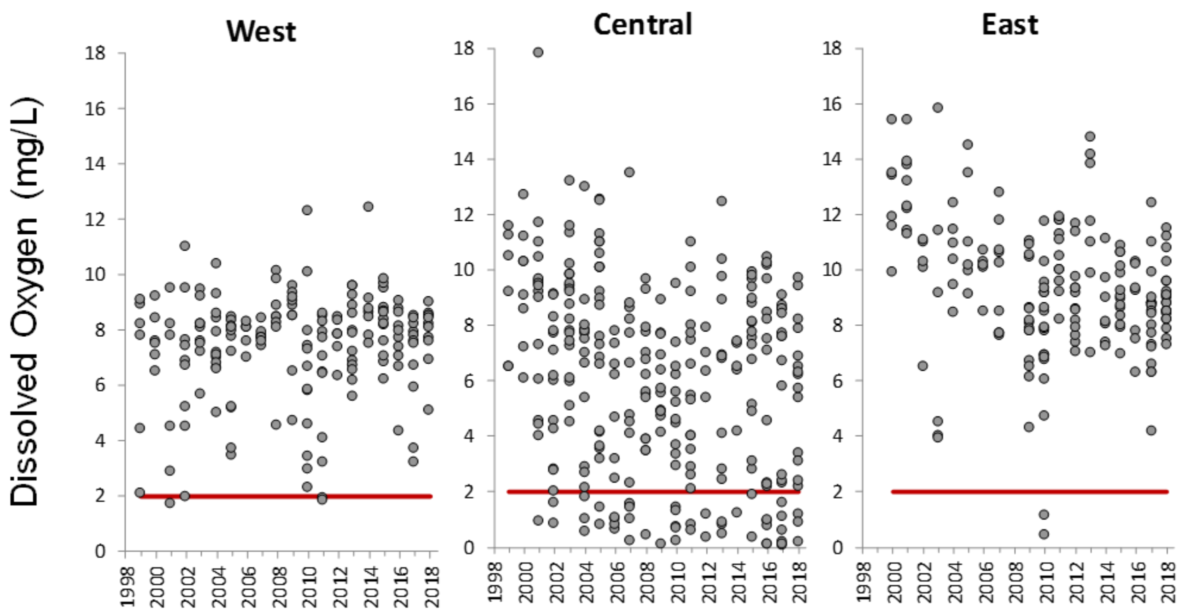



Figure 1.0.3. Summer (June-August) bottom dissolved oxygen (mg/L) concentrations for offshore sites by basin in Lake Erie, 1999-2018. The red horizontal line represents 2 mg/L, a level below which oxygen becomes limiting to the distribution of many temperate freshwater fishes. Data included in this analysis by basin and station: West – 4, 6, 21; Central – 8, 10, 11, 24; East – 16, 18, 19.

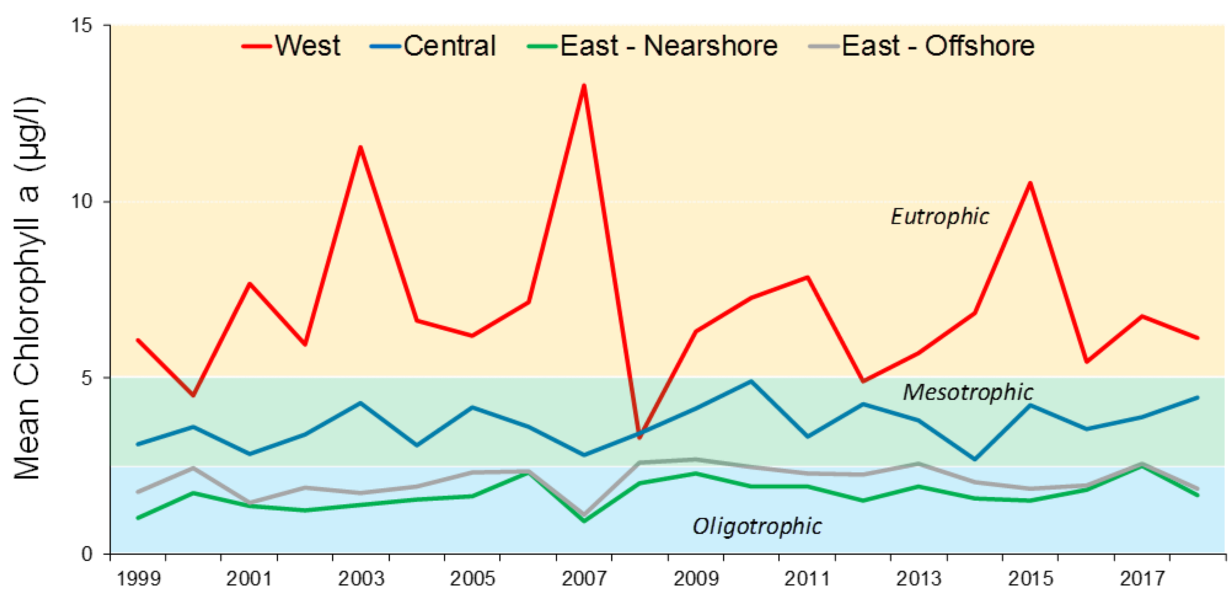



Figure 1.0.4. Mean chlorophyll *a* concentration (µg/L), weighted by month, by basin in Lake Erie, 1999-2018. The east basin is separated into nearshore and offshore. Shaded areas represent trophic class ranges.

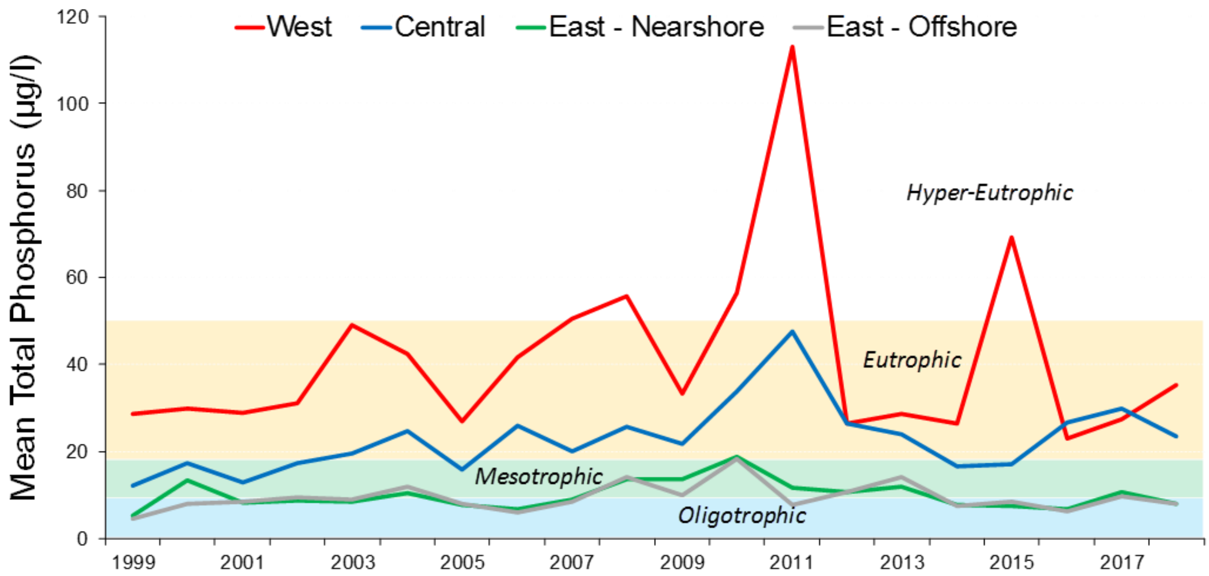



Figure 1.0.5. Mean total phosphorus (µg/L), weighted by month, for offshore sites by basin in Lake Erie, 1999-2018. The east basin is separated into nearshore and offshore. Shaded areas represent the trophic class ranges.

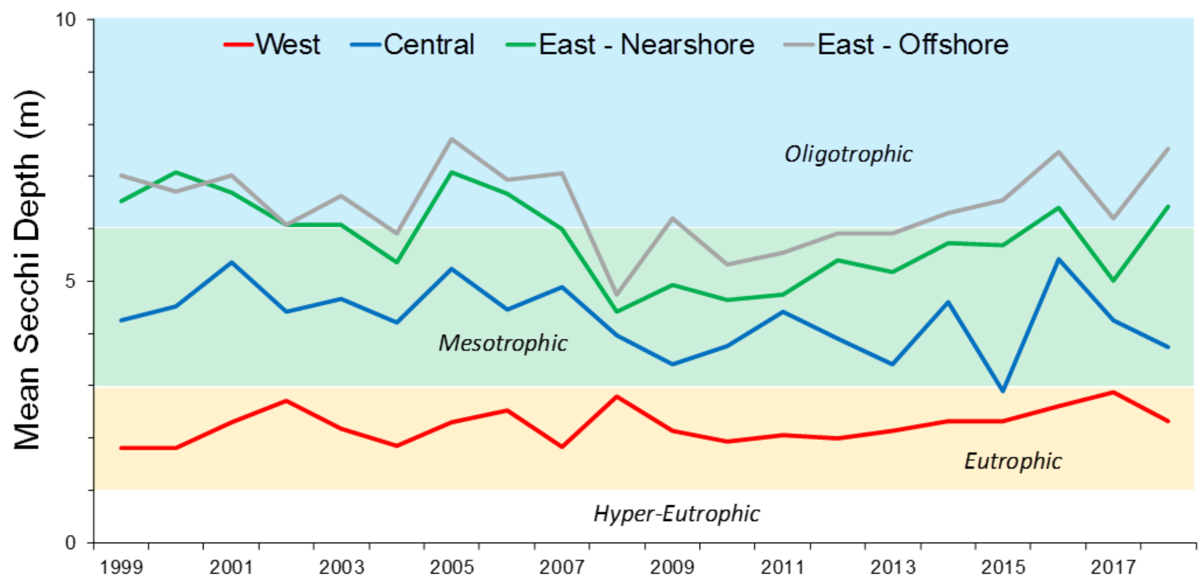



Figure 1.0.6. Mean summer (June-August) Secchi depth (m), weighted by month, by basin in Lake Erie, 1999-2018. The east basin is separated into inshore and offshore. Yellow shaded areas represent the targeted trophic class range.

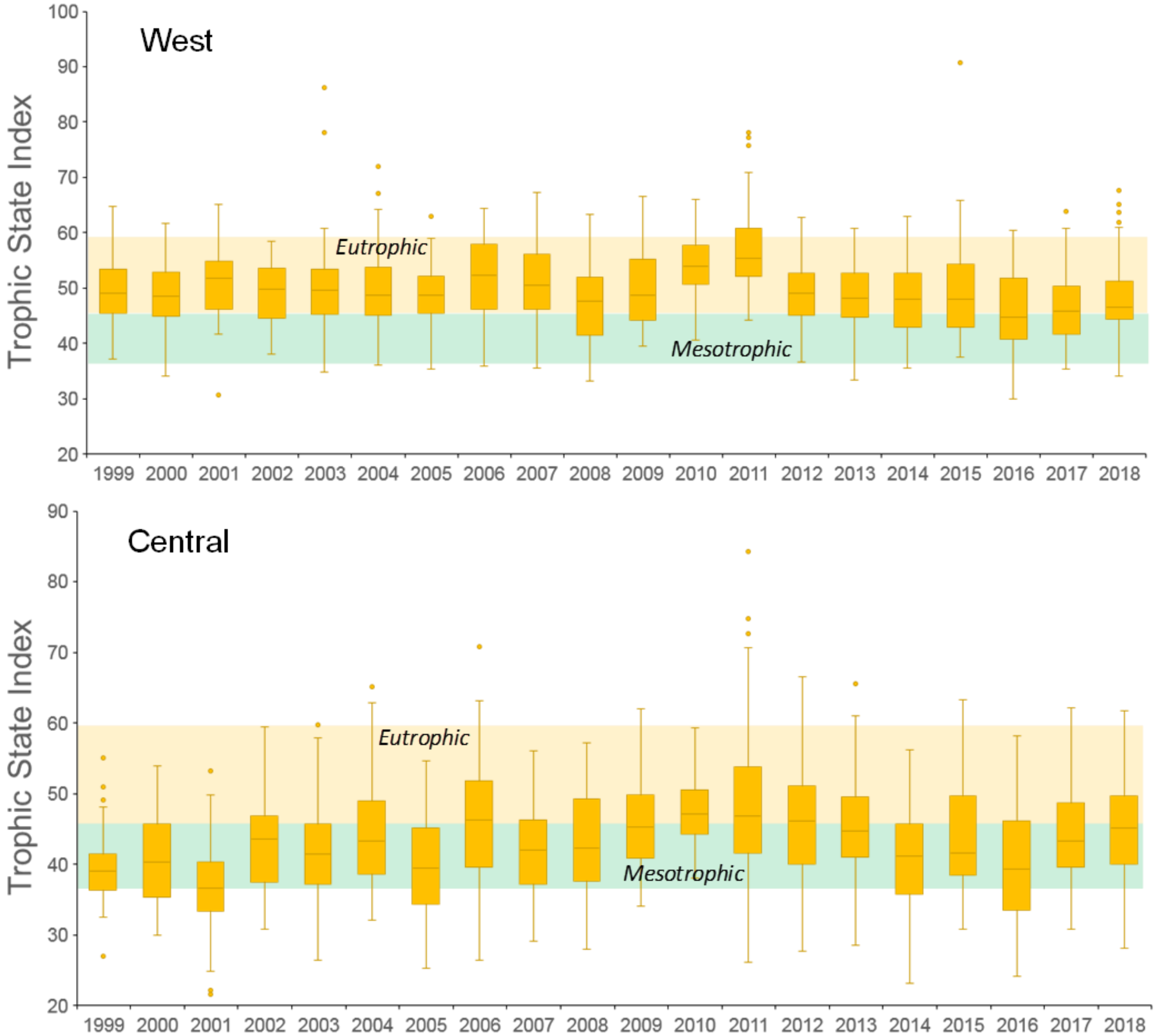



Figure 1.0.7. Box and whisker plot of trophic state indices (TSI) by basin in Lake Erie, 1999-2018. The east basin is separated into nearshore and offshore. Shaded areas represent trophic class ranges. Boxes indicate 25th and 75th quartiles of the values with the median value as the horizontal line. Vertical lines show the range of values with individual points representing outliers.

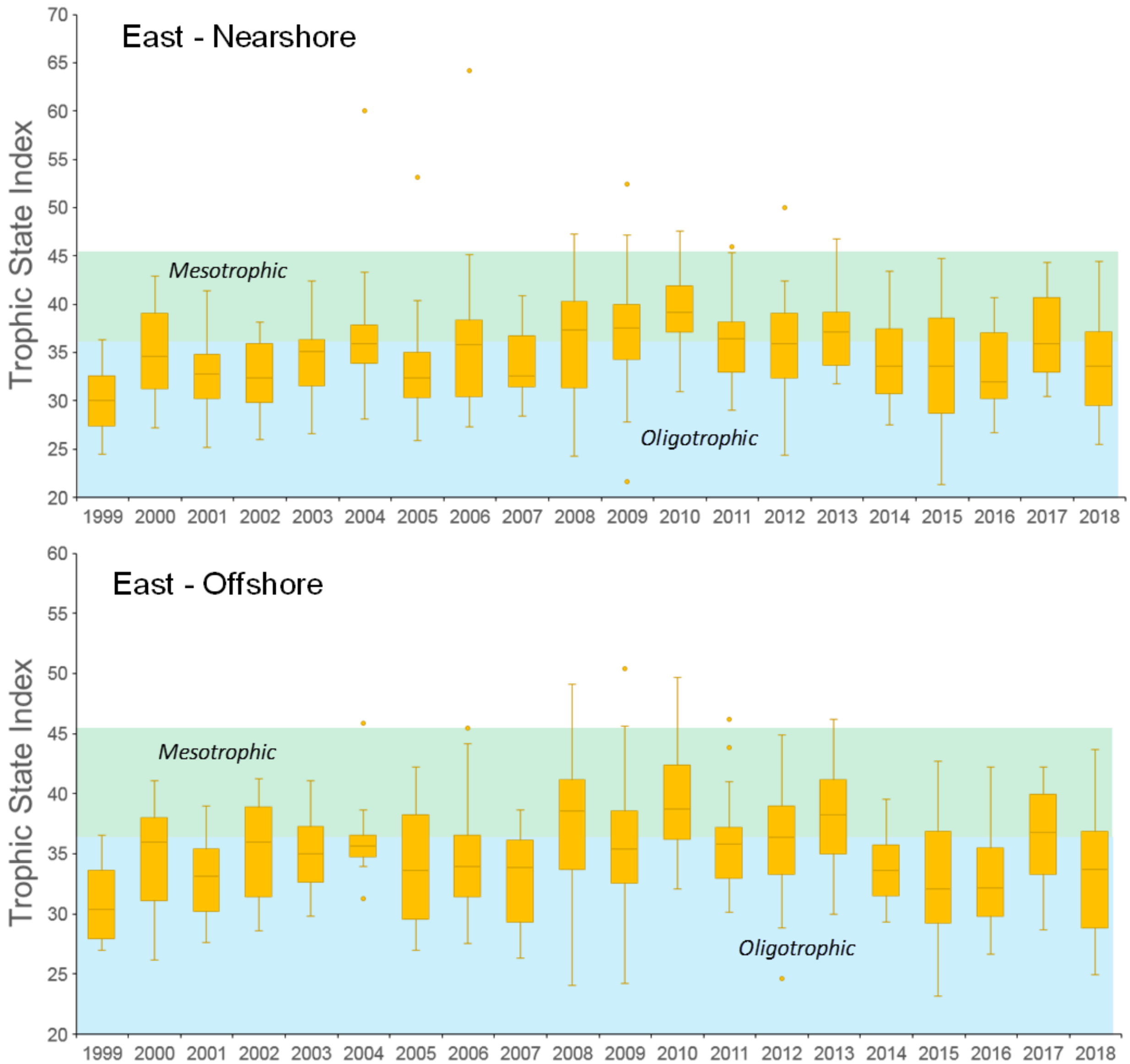



Figure 1.0.7. (Continued) Box and whisker plot of trophic state indices (TSI) by basin in Lake Erie, 1999-2018. The east basin is separated into nearshore and offshore. Shaded areas represent trophic class ranges. Boxes indicate 25th and 75th quartiles of the values with the median value as the horizontal line. Vertical lines show the range of values with individual points representing outliers.

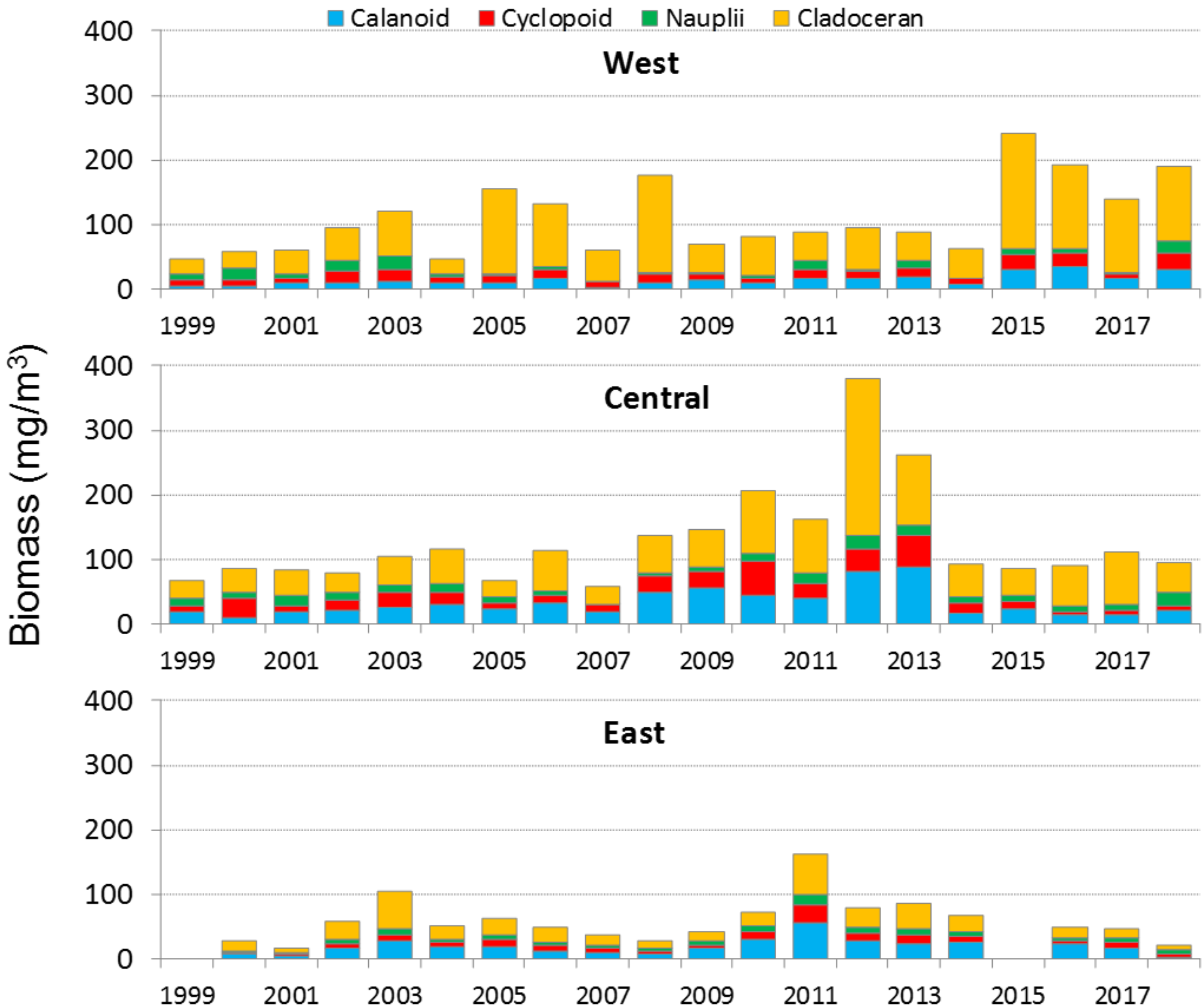



Figure 1.0.8. Mean zooplankton biomass (mg/m$^3$) by major taxonomic group by basin, 1999 through 2018. There is no data for 1999 and 2015 in the east basin. West basin includes stations 3 through 6, central basin stations 7 through 12, and east basin stations 15 through 18. Data excludes rotifers and 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.**

## 2.1 Synopsis of 2018 Forage Status and Trends

### Eastern Basin

- Total forage fish abundance in 2018 increased in Ontario over 2017 but remained well below the long-term mean. Abundance decreased in New York. Pennsylvania did not sample due to vessel constraints
- Catches of young-of-the-year (age-0) and yearling-and-older (age-1+) Rainbow Smelt were below long-term means in both jurisdictions
- Young-of-the-year Emerald Shiner catches were low in both jurisdictions. Yearling-and-older catches were low in Ontario but high in New York, above long-term means
- Catches of age-0 Yellow Perch have generally been above long-term means in recent years
- Round Goby densities were generally consistent with long-term means in Ontario and below long-term means in New York
- Catches of all other species were low

### Central Basin

- In Ohio, overall forage abundance has generally decreased since 2012
- In 2018, overall forage abundance decreased due to poor recruitment of all species except age-0 Yellow Perch and White Perch
- Young-of-the-year Yellow Perch abundance increased in Ohio indices and were above long-term means
- Young-of-the-year and age-1+ Rainbow Smelt indices were well below long-term means
- Emerald Shiner were caught in western areas of the basin for the first time in two years, but the index is extremely low.
- Round Goby indices declined and were some of the lowest estimates in the time series
- Gizzard Shad indices declined and were some of the lowest in the time series

**West Basin**

- Forage abundance in 2018 was near the ten-year mean
- Forage biomass increased 33% from 2018
- Young-of-the-year Walleye recruitment was the largest year class on record, 40% greater than the historic 2003-year class
- Young-of-the-year Yellow Perch recruitment doubled relative to last year; the 2018-year class was three times the ten-year mean
- White Bass recruitment declined 67% from a strong 2017-year class
- Young-of-the-year White Perch density declined 20% from 2017 but remained the most abundant catch (61%)
- Young-of-the-year Rainbow Smelt returned to historic lows after a large 2017-year class
- Young-of-the-year and age-1+ Emerald Shiner indices increased for the second straight year, although they remain well below ten-year means (19% and 5%, respectively)
- Round Goby abundance was the lowest since 1997, the year they were first detected
- Age-0 Freshwater Drum, age-0 Trout-perch, and age-1+ Trout-perch relative abundances were all well above their ten-year averages

## 2.2 Eastern Basin (C. May, J. Markham and M. Hosack)

Forage fish abundance and distribution is determined primarily from long-term bottom trawl assessments conducted by the basin agencies (also see East Basin Hydroacoustic Survey, Section 3.1). In 2018, a total of 34 trawl tows were sampled across New York waters (NYSDEC; n=27 years) and 109 trawl tows in nearshore and offshore Long Point Bay of Ontario (OMNRF; n=38 and 35 years, respectively). Pennsylvania did not sample in 2018 due to vessel constraints (Figure 2.2.1).

In 2018, forage fish densities decreased in New York and increased slightly in Ontario, though still low in the time series (Figure 2.2.2). Rainbow Smelt is the most abundant forage species in most years and jurisdictions (Figure 2.2.2). In 2018, Rainbow Smelt catches were primarily composed of age-0 individuals; very low densities of age-1+ Rainbow Smelt were caught in either jurisdiction (Table 2.2.1). Young-of-the-year Emerald Shiner catches were again low in 2018 but age-1+ catches were the second highest in ten years in New York waters (Table 2.2.1). Yellow Perch are a forage fish when at the age-0 stage and have become more common in predator diets (see Section 4). Catches have generally been up in recent years (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 both jurisdictions (Table 2.2.1). Catches of all other species were low in 2018 (Table 2.2.1).

## 2.3 Central Basin (J. Deller and M. Hosack)

Routine bottom trawl surveys in the central basin began in Pennsylvania in 1982 and in Ohio in 1990 to assess age-0 percid and forage fish abundance and distributions. Trawl locations in Pennsylvania range from 13 to 24 m depth and Ohio trawl locations range from 5 to >20 m 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 2018, 24 trawl tows were completed in Ohio waters of the central basin, Pennsylvania was not able to trawl due to vessel repairs. 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 development, results and analysis of the new survey will be included in the Forage Task Group Report.

Forage abundance in Ohio waters has generally decreased since 2012. In 2018, most forage species continued to decline and are at the lowest densities since 1993 (Figure 2.3.2). Spiny-rayed species increased slightly from 2017 but remain well below average.

In 2018, indices for the primary forage species, Rainbow Smelt, Emerald Shiner, Round Goby and Gizzard Shad were all well below long-term means in Ohio (Table 2.3.1; 2.3.2). Young-of-the-year andd age-1+ indices for all species were some of the lowest in the last ten years.

Since 2005, Yellow Perch cohorts in the central basin have tended to be strongest in the east relative to the west. In 2018, Yellow Perch age-0 indices in Ohio increased over the last two years and are slightly above long-term means (Table 2.3.1). Yearling-and-older indices in both Ohio surveys remain 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 and age-1+ indices across the central basin were mixed. White Perch densities increased in Ohio East and were above the long-term mean (Table 2.3.1). Density estimates in Ohio West decreased and were well below the long-term mean. Yearling-and-older White Perch densities have been decreasing since 2016 in Ohio and are some of the lowest indices in the time series (Table 2.3.2).

## 2.4 West Basin (Z. Slagle and E. Weimer)

### History

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. This 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 new 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 the vessels administering the western basin Interagency Trawling Program (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 (ha)) 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).

**2018 Results**

In 2018, hypolimnetic dissolved oxygen levels were below the 2 mg per liter threshold at three sites during the August trawling survey (two were located southeast of Pelee Island, one was in nearshore waters west of Point Pelee – all three in Canadian waters). In total, data from 71 sites were used in 2018 (Figure 2.4.1).

After a 2017 total forage abundance that was above the 10-year and overall mean abundance, the total abundance in 2018 declined 11% but was near the ten-year mean (Figure 2.4.2). Spiny-rayed abundance was similar to 2017 (-2%), while soft-rayed species increased by 17%, continuing a three-year upswing. Clupeid abundance declined 75% from 2017. Total forage density averaged 5,113 fish per hectare (fish/ha) across the western basin, declining 11% from 2017 but remaining above the ten-year mean (4,966 fish/ha). Clupeid density was 206 fish/ha (ten-year mean 903 fish/ha), soft-rayed fish density was 306 fish/ha (mean 502 fish/ha), and spiny-rayed fish density was 4,600 fish/ha (mean 3,560 fish/ha). Relative abundance of the dominant species includes: age-0 White Perch (61%), age-0 Yellow Perch (19%), age-0 Walleye (5%), followed by Gizzard Shad and adult Troutperch (4% each). Total forage biomass in 2018 increased 33% compared to 2017 (Figure 2.4.3). Relative biomass of clupeid, soft-rayed, and spiny-rayed species in 2017 was 7%, 2%, and 91%, respectively, and differed from their respective ten-year averages of 21%, 4%, and 75%.

Recruitment of individual species remains highly variable in the western basin. Age-0 Walleye relative abundance in 2018 was the highest ever recorded in the time series (255/ha), twelve times greater than the ten-year mean (21/ha) and 40% higher than the historic 2003 year class. Young-of-the-year Yellow Perch (959/ha; Figure 2.4.4) doubled relative to 2017 and was well above the long-term mean (340/ha). Young-of-the-year White Perch (3,141/ha) declined 20% from 2017 but was near the ten-year average (2,972/ha). Young-of-the-year White Bass (81/ha) declined 67% from a large 2017 year class. Densities of age-0 Rainbow Smelt (0.1/ha) and age-1+ Rainbow Smelt density (0.3/ha) returned to minimal levels after unusually high densities in 2017. Young-of-the-year Gizzard Shad (206/ha) declined 75% from 2017, well below the ten-year mean (903/ha) and continued a trend of high annual variation (Figure 2.4.5). Densities of age-0 (11/ha) and age-1+ Emerald Shiners (3/ha) increased for the second straight year, although numbers of each remain well below ten-year averages (Figure 2.4.6). Age-0 Silver Chub relative abundance (2.9/ha) was the greatest in three years, three times the ten-year mean (0.9/ha). Age-1+ Spottail Shiner 2018 density (3.9/ha) rebounded from the lowest density of the time series in 2017 (0.4/ha). Young-of-the-year Freshwater Drum density in 2018 (163/ha) was the highest since 2012. Young-of-the-year and age-1+ Troutperch densities in 2018 (226 and 35/ha, respectively) were well above their ten-year means (70 and 20/ha, respectively). Average total lengths for most age-0 sportfish (Walleye, Yellow Perch, White Bass, White Perch, and Smallmouth Bass) were all near their ten-year means, while age-0 Walleye mean total length (138 mm) continued a six-year decline.

**Summary of 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 hectares, depending on tow time. Our otter trawl has a 33-foot head rope and 3/8-inch terminal mesh and is deployed with a single warp and 150-foot bridle. Captured fish are passed through a 1.25-inch screen to grade out forage and age-0 sportfish. In 2018 all eight sites (Figure 2.4.7, Table 2.4.2) were sampled between August 6$^{th}$ and August 8$^{th}$.

The 2018 survey had by far the highest density of total forage and age-0 fish (10,603/ha) across the five-year time series of the survey (Table 2.4.3). This substantial increase from previous years was driven by a large abundance of age-0 White Perch (8,100/ha) and age-0 Yellow Perch (1,683/ha). This catch of age-0 White Perch and age-0 Yellow Perch were both the highest observed in our time series. Young-of-the-year Gizzard Shad declined from last year (259.4/ha in 2018 compared to 730.9 per ha in 2017) but 2018 was still the second highest density observed in our time series. In 2018, we also observed the highest densities of age-0 Freshwater Drum (45.6/ha) and Trout-Perch (290.4/ha) in our time series (Table 2.4.3). Spottail Shiners rebounded slightly in 2018 from a low in 2017 but were below their five-year mean. Finally, the 2018 age-0 Walleye catch of 50.3/ha, was the highest observed in the time series, up substantially from 2017 (16.6/ha).

The continued development of this dataset will allow for the evaluation of trends in forage abundance and the recruitment of sportfish in Michigan's Lake Erie waters in future years. However, based on the current time series 2018 appears to have been an exceptional year for the production of age-0 White Perch, Yellow Perch and Walleye in Michigan's Lake Erie waters. Michigan Plans to continue forage trawling at these sites annually to contribute to lake wide estimates of forage and age-0 sportfish abundance.

Table 2.2.1 Relative abundance of selected forage fish species in eastern Lake Erie from bottom trawl surveys conducted by Ontario, New York, and Pennsylvania for the most recent 10-year period. Indices are reported as arithmetic mean number caught per hectare for age-0, age-1+, and ages combined (all). Long-term means are reported as the mean of the annual trawl indice for the most recent 10-year period (2009-2018) and for the two most recent completed decades. Agency trawl surveys are described below.

| Species | Age Group | Trawl Survey | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 10-Yr & Long-term Avg. by decade 10-Yr | 2000's | 1990's |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Rainbow Smelt** | **Age-0** | ON-DW | 148.2 | 326.9 | 509.2 | 1657.7 | 217.9 | 1001.6 | 3245.2 | 538.3 | 372.3 | 584.8 | 860.2 | 1267.2 | 431.7 |
| | **Age-0** | NY-Fa | 73.4 | 1453.6 | 1621.7 | 424.4 | 755.2 | 5520.2 | 2930.7 | 2901.3 | 3225.3 | 861.7 | 1976.7 | 1416.9 | 1468.0 |
| | **Age-0** | PA-Fa | 47.7 | NA | NA | 560.2 | NA | NA | 129.1 | 166.9 | 872.3 | NA | 355.3 | 106.0 | 421.1 |
| | **Age-1+** | ON-DW | 1654.3 | 222.7 | 277.1 | 367.8 | 165.3 | 4.6 | 411.0 | 20.2 | 0.1 | 0.1 | 312.3 | 490.1 | 358.6 |
| | **Age-1+** | NY-Fa | 3088.6 | 1023.8 | 656.8 | 22.7 | 45.8 | 24.8 | 590.1 | 5.8 | 67.5 | 65.5 | 559.1 | 1004.2 | 583.3 |
| | **Age-1+** | PA-Fa | 407.2 | NA | NA | 22.3 | NA | NA | 39.6 | 0.0 | 0.5 | NA | 93.9 | 202.2 | 1108.8 |
| **Emerald Shiner** | **Age-0** | ON-DW | 54.8 | 117.6 | 70.3 | 438.3 | 58.7 | 2.9 | 346.7 | 2.0 | 0 | 0.7 | 109.2 | 422.3 | 52.3 |
| | **Age-0** | NY-Fa | 49.7 | 64.6 | 3006.7 | 96.8 | 130.9 | 526.3 | 137.6 | 6.1 | 51.6 | 23.8 | 409.4 | 174.4 | 115.1 |
| | **Age-0** | PA-Fa | 1063.0 | NA | NA | 14.8 | NA | NA | 68.2 | 0.0 | 0 | NA | 229.2 | 289.3 | 39.9 |
| | **Age-1+** | ON-DW | 40.1 | 30.7 | 201.1 | 119.2 | 188.6 | 2.5 | 6.5 | 28.2 | 0.4 | 1.3 | 61.9 | 741.1 | 37.7 |
| | **Age-1+** | NY-Fa | 160.4 | 21.1 | 1874.0 | 96.2 | 67.1 | 822.8 | 24.8 | 22.2 | 4.5 | 1108.3 | 420.1 | 294.4 | 108.1 |
| | **Age-1+** | PA-Fa | 1360.3 | NA | NA | 86.9 | NA | NA | 146.9 | 0.0 | 0 | NA | 318.8 | 761.3 | 10.3 |
| **Spottail** | **Age-0** | ON-OB | 3.7 | 3.0 | 2.5 | 19.1 | 8.1 | 5.0 | 5.8 | 4.1 | 38.2 | 36.7 | 12.6 | 107.7 | 815.9 |
| | **Age-0** | NY-Fa | 0.1 | 6.7 | 0.7 | 1.8 | 0.0 | 0.1 | 0.0 | 0.1 | 0.4 | 3.5 | 1.3 | 5.7 | 20.4 |
| | **Age-0** | PA-Fa | 1.1 | NA | NA | 0.0 | NA | NA | 0.0 | 0.0 | 0 | NA | 0.2 | 0.2 | 3.6 |
| | **Age-1+** | ON-OB | 3.3 | 2.1 | 0.5 | 1.6 | 3.0 | 0.2 | 1.5 | 0.0 | 2.8 | 3.3 | 1.8 | 10.1 | 74.6 |
| | **Age-1+** | NY-Fa | 5.2 | 10.7 | 29.7 | 2.1 | 0.3 | 0.2 | 0.0 | 9.3 | 0.8 | 6.2 | 6.4 | 6.6 | 4.0 |
| | **Age-1+** | PA-Fa | 0.0 | NA | NA | 0.1 | NA | NA | 0.0 | 0.0 | 0 | NA | 0.0 | 0.0 | 5.7 |
| **Alewife** | **Age-0** | ON-DW | 0.1 | 0.9 | 2.1 | 707.3 | 17.7 | 0.0 | 0.7 | 0.8 | 36.1 | 0.0 | 76.6 | 20.2 | 231.2 |
| | **Age-0** | ON-OB | 1.9 | 0.0 | 6.8 | 6.0 | 26.1 | 0.0 | 3.4 | 0.0 | 28.3 | 0.0 | 7.3 | 74.1 | 88.5 |
| | **Age-0** | NY-Fa | 0.0 | 15.8 | 12.7 | 188.6 | 223.9 | 0.0 | 5.6 | 0.8 | 297.7 | 8.7 | 75.4 | 87.0 | 53.4 |
| | **Age-0** | PA-Fa | 0.0 | NA | NA | 4.6 | NA | NA | 0.0 | 0.0 | 0 | NA | 0.9 | 1.0 | 2.2 |

"**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 is conducted weekly during October at 4 fixed stations in the offshore waters of Outer Long Point Bay using a 10-m trawl with 13-mm mesh cod end liner.

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

ON-IB — Trawling is conducted weekly during 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-Composite Index — 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 2.2.1 (Continued) Relative abundance of selected forage fish species in eastern Lake Erie from bottom trawl surveys conducted by Ontario, New York, and Pennsylvania for the most recent 10-year period. Indices are reported as arithmetic mean number caught per hectare for age-0, age-1+, and ages combined (all). Long-term means are reported as the mean of the annual trawl indice for the most recent 10-year period (2009-2018) and for the two most recent completed decades. Agency trawl surveys are described below.

| Species | Age Group | Trawl Survey | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 10-Yr & Long-term Avg. by decade 10-Yr | 2000's | 1990's |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gizzard** | **Age-0** | ON-DW | 0.4 | 13.3 | 18.9 | 47.6 | 0.0 | 0.0 | 0.4 | 1.9 | 1.9 | 0.0 | 8.4 | 19.2 | 7.5 |
| **Shad** | **Age-0** | ON-OB | 0.0 | 3.8 | 3.4 | 20.0 | 0.3 | 0.4 | 10.1 | 0.0 | 4.1 | 1.6 | 4.4 | 6.9 | 13.4 |
| | **Age-0** | NY-Fa | 5.4 | 42.0 | 15.4 | 4.9 | 3.9 | 0.6 | 3.3 | 1.9 | 3.8 | 2.1 | 8.3 | 11.6 | 4.4 |
| | **Age-0** | PA-Fa | 0.0 | NA | NA | 1.0 | NA | NA | 41.5 | 0.0 | 0 | NA | 8.5 | 0.0 | 0.3 |
| **White** | **Age-0** | ON-DW | 0.6 | 1.6 | 0.0 | 0.8 | 0.0 | 0.0 | 0.5 | 96.1 | 0.3 | 1.0 | 10.1 | 2.7 | 1.8 |
| **Perch** | **Age-0** | ON-OB | 0.0 | 0.0 | 0.0 | 0.9 | 0.0 | 0.0 | 0.2 | 0.0 | 0.7 | 38.6 | 4.0 | 2.5 | 17.6 |
| | **Age-0** | NY-Fa | 20.7 | 161.3 | 37.5 | 18.7 | 4.5 | 36.1 | 17.3 | 79.3 | 44.2 | 43.2 | 46.3 | 70.7 | 30.1 |
| | **Age-0** | PA-Fa | 598.5 | NA | NA | 380.0 | NA | NA | 287.9 | 2.3 | 150.4 | NA | 283.8 | 267.8 | 71.5 |
| **Trout** | **All** | ON-DW | 0.8 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0 | 0.0 | 0.1 | 0.9 | 0.6 |
| **Perch** | **All** | NY-Fa | 530.1 | 473.7 | 671.4 | 347.8 | 152.7 | 64.9 | 33.1 | 26.1 | 8.6 | 6.6 | 231.5 | 815.0 | 417.5 |
| | **All** | PA-Fa | 558.8 | NA | NA | 52.2 | NA | NA | 2.1 | 0.2 | 4.2 | NA | 123.5 | 179.5 | 64.6 |
| **Yelow** | **Age-0** | ON-Composite | 0.4 | 51.8 | 176.7 | 27.4 | 0.5 | 28.4 | 58.5 | 360.6 | 65.5 | 328.8 | 109.9 | 33.0 | 79.5 |
| **Perch** | **Age-0** | NY-Fa | 11.9 | 197.7 | 89.5 | 280.0 | 4.4 | 274.2 | 68.6 | 2178.2 | 247.0 | 662.4 | 401.4 | 40.2 | 251.0 |
| | **Age-0** | PA-Fa | 70.2 | NA | NA | 286.8 | NA | NA | 69.3 | 56.3 | 300.4 | NA | 156.6 | 259.8 | 27.4 |
| **Round** | **All** | ON-DW | 43.6 | 9.7 | 125.4 | 129.0 | 14.5 | 0.5 | 67.2 | 300.9 | 137.9 | 64.2 | 89.3 | 216.7 | 0.0 |
| **Goby** | **All** | ON-OB | 91.2 | 67.6 | 103.3 | 68.0 | 76.3 | 98.5 | 359.1 | 54.0 | 93.5 | 315.1 | 132.7 | 87.3 | 0.1 |
| | **All** | ON-IB | 280.5 | 135.1 | 114.6 | 80.2 | 49.6 | 95.4 | 151.6 | 160.8 | 28.2 | 110.5 | 120.7 | 136.1 | 0.1 |
| | **All** | NY-Fa | 515.7 | 177.8 | 170.2 | 184.9 | 86.1 | 140.3 | 441.6 | 104.9 | 146.9 | 164.5 | 213.3 | 656.0 | 1.0 |
| | **All** | PA-Fa | 350.1 | NA | NA | 32.1 | NA | NA | 47.2 | 85.6 | 30.1 | NA | 109.0 | 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**

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

ON-IB — Trawling is conducted weekly during 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-Composite Index — 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 Relative abundance (arithmetic mean number per hectare) of selected age-0 species from fall trawl surveys in the central basin, Ohio and Pennsylvania, Lake Erie, from 2008-2018. 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 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Mean |
| Yellow | OH West | 32.1 | 1.6 | 41.1 | 10.3 | 69.2 | 8.9 | 37.7 | 19.6 | 0.5 | 19.0 | 28.4 | 24.0 |
| Perch | OH East | 52.8 | 0.5 | 96.3 | 15.1 | 134.4 | 8.9 | 49.1 | 18.6 | 1.6 | 39.1 | 50.8 | 41.6 |
| | PA | 863.4 | 14.2 | - | - | 481.6 | 28.0 | - | 107.0 | 332.9 | 92.9 | - | 274.3 |
| White | OH West | 470.6 | 379.0 | 254.8 | 346.6 | 1709.6 | 174.7 | 135.0 | 371.0 | 15.3 | 200.8 | 163.1 | 405.7 |
| Perch | OH East | 91.6 | 34.6 | 190.3 | 72.1 | 661.9 | 200.1 | 99.4 | 338.8 | 5.4 | 44.4 | 248.8 | 173.9 |
| | PA | 199.0 | 146.3 | - | - | 380.1 | 2.2 | - | 758.6 | 165.5 | 149.3 | - | 257.3 |
| Rainbow | OH West | 765.8 | 267.8 | 776.2 | 29.8 | 84.4 | 126.0 | 747.8 | 447.0 | 219.4 | 347.1 | 1.7 | 381.1 |
| Smelt | OH East | 3997.7 | 0.3 | 421.6 | 247.3 | 319.1 | 12.8 | 1709.5 | 236.4 | 1383.4 | 898.7 | 1.7 | 922.7 |
| | PA | 552.2 | 23.1 | - | - | 10.4 | 132.8 | - | 148.1 | 506.4 | 319.4 | - | 241.8 |
| Round | OH West | 19.1 | 24.5 | 28.4 | 100.8 | 18.2 | 17.5 | 6.3 | 56.8 | 14.5 | 27.3 | 2.8 | 31.3 |
| Goby | OH East | 26.3 | 1.0 | 41.8 | 256.0 | 53.9 | 45.8 | 86.2 | 66.8 | 29.9 | 31.1 | 4.2 | 63.9 |
| | PA | 227.1 | 72.0 | - | - | 3.3 | 11.7 | - | 124.1 | 47.2 | 210.3 | - | 99.4 |
| Emerald | OH West | 25.1 | 7.5 | 8.8 | 361.7 | 951.3 | 2218.5 | 1369.3 | 3.5 | 0.0 | 0.0 | 1.3 | 494.6 |
| Shiner | OH East | 20.2 | 1.7 | 234.9 | 103.7 | 2188.5 | 306.2 | 650.1 | 13.2 | 0.0 | 0.0 | 0 | 351.9 |
| | PA | 0.0 | 304.6 | - | - | 0.0 | 31.6 | - | 57.7 | 2.2 | 0.0 | - | 56.6 |
| Spottail | OH West | 3.4 | 0.4 | 0.0 | 0.6 | 0.0 | 0.0 | 2.5 | 0.0 | 0.0 | 0.0 | 0 | 0.7 |
| Shiner | OH East | 0.2 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0 | 0.1 |
| | PA | 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 | 0.0 | 52.1 | 0.0 | 0.0 | 0.0 | 30.3 | 0 | 8.2 |
| | OH East | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 36.1 | 0.0 | 0.0 | 0.0 | 223.6 | 0 | 26.0 |
| | PA | 0.0 | 0.0 | - | - | 2.8 | 5.0 | - | 0.0 | 4.0 | 0.0 | - | 1.7 |
| Gizzard | OH West | 34.3 | 52.6 | 2.6 | 675.8 | 98.7 | 304.2 | 33.8 | 568.0 | 12.0 | 201.6 | 13.7 | 198.4 |
| Shad | OH East | 63.1 | 3.9 | 8.5 | 4.2 | 28.7 | 39.5 | 7.3 | 455.6 | 1.2 | 214.8 | 12.3 | 82.7 |
| | PA | 0.0 | 0.0 | - | - | 0.0 | 0.0 | - | 8.7 | 0.0 | 0.5 | - | 1.3 |
| Trout- | OH West | 0.3 | 0.5 | 0.7 | 1.3 | 0.0 | 0.1 | 0.3 | 0.4 | 0.0 | 0.0 | 0 | 0.4 |
| perch | OH East | 0.1 | 0.2 | 1.4 | 2.2 | 0.2 | 0.0 | 0.6 | 1.2 | 0.0 | 0.2 | 0 | 0.6 |
| | PA | 126.1 | 28.2 | - | - | 0.0 | 0.0 | - | 2.2 | 4.6 | 4.2 | - | 23.6 |

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

Table 2.3.2 Relative abundance (arithmetic mean number per hectare) of selected age-1+ species from fall trawl surveys in the central basin, Ohio and Pennsylvania, Lake Erie, from 2008-2018. 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 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Mean |
| Species | Survey | | | | | | | | | | | | |
| Yellow | OH West | 55.0 | 20.2 | 11.9 | 6.3 | 7.4 | 34.9 | 15.4 | 41.3 | 5.0 | 3.7 | 7.9 | 20.1 |
| Perch | OH East | 26.4 | 139.4 | 12.4 | 55.5 | 23.3 | 109.5 | 24.2 | 30.2 | 8.7 | 7.6 | 6.6 | 43.7 |
| | PA | 76.4 | 121.8 | - | - | 117.7 | 73.7 | - | 59.0 | 61.2 | 114.1 | - | 89.1 |
| White | OH West | 81.7 | 45.8 | 32.6 | 25.9 | 45.8 | 195.9 | 5.8 | 1.7 | 47.5 | 29.9 | 3.5 | 51.3 |
| Perch | OH East | 36.6 | 282.3 | 44.8 | 49.8 | 7.7 | 546.9 | 4.4 | 1.4 | 55.4 | 17.6 | 6.6 | 104.7 |
| | PA | 4.2 | 62.6 | - | - | 7.8 | 18.4 | - | 78.9 | 4.0 | 19.6 | - | 27.9 |
| Rainbow | OH West | 7.4 | 368.8 | 9.0 | 15.6 | 9.1 | 8.1 | 34.9 | 340.8 | 0.5 | 53.8 | 16.7 | 84.8 |
| Smelt | OH East | 48.7 | 98.2 | 49.8 | 186.0 | 95.4 | 200.7 | 6.2 | 295.4 | 17.1 | 35.7 | 9.4 | 103.3 |
| | PA | 3.5 | 406.5 | - | - | 20.5 | 25.1 | - | 69.7 | 5.0 | 0.9 | - | 75.9 |
| Round | OH West | 64.8 | 60.4 | 44.0 | 68.6 | 11.8 | 24.3 | 6.9 | 35.8 | 3.7 | 19.6 | 4.5 | 34.0 |
| Goby | OH East | 167.8 | 19.3 | 36.0 | 118.1 | 27.0 | 46.3 | 89.1 | 72.4 | 16.1 | 14.3 | 3.5 | 60.6 |
| | PA | 326.6 | 76.0 | - | - | 72.9 | 8.6 | - | 50.3 | 12.7 | 183.9 | - | 104.4 |
| Emerald | OH West | 601.2 | 127.7 | 51.5 | 138.2 | 998.8 | 298.0 | 55.8 | 0.9 | 1.3 | 0.0 | 0 | 227.3 |
| Shiner | OH East | 1159.4 | 167.8 | 375.1 | 149.7 | 433.2 | 8.4 | 333.5 | 1.8 | 0.0 | 0.0 | 0 | 262.9 |
| | PA | 28.0 | 172.5 | - | - | 8.9 | 17.2 | - | 179.5 | 6.4 | 0.0 | - | 58.9 |
| Spottail | OH West | 2.4 | 1.9 | 0.0 | 20.7 | 0.0 | 0.5 | 1.7 | 0.0 | 0.0 | 0.0 | 0.7 | 2.7 |
| Shiner | OH East | 2.9 | 0.0 | 0.0 | 3.1 | 3.0 | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 1.2 |
| | PA | 0.0 | 0.0 | - | - | 0.0 | 0.0 | - | 0.0 | 0.0 | 0.0 | - | 0.0 |
| Trout- | OH West | 3.3 | 0.9 | 0.7 | 3.3 | 1.6 | 3.3 | 0.6 | 0.7 | 0.0 | 0.4 | 2 | 1.5 |
| perch | OH East | 8.4 | 1.5 | 5.0 | 7.9 | 11.7 | 1.0 | 0.4 | 3.0 | 0.1 | 0.3 | 5.3 | 3.9 |
| | PA | 61.7 | 127.5 | - | - | 30.4 | 9.3 | - | 8.3 | 2.4 | 5.2 | - | 35.0 |

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

Table 2.4.1. Mean catch-per-unit-effort (CPUE) 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 (#/ha) | 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 |
| | Troutperch | 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 |
| | Troutperch | 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 |
| | Troutperch | 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 |
| | Troutperch | 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 2018 Michigan forage trawl sampling dates, locations, and site conditions.

| Date | 2min Grid | St_Lat | St_Long | End_Latd | End_Long | Stime (24hr) | Towtime (min) | St_depth (m) | End_depth (m) | Temp (ºC) | Secchi (m) | Area_ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/06/2018 | 3 | 41.9586 | -83.1499 | 41.9612 | -83.1487 | 12:21 | 5 | 7.31 | 7.31 | 25.3 | 1.70 | 0.27 |
| 08/06/2018 | 895 | 41.9222 | -83.2075 | 41.9277 | -83.2066 | 13:21 | 10 | 8.53 | 8.53 | 25.5 | 1.13 | 0.40 |
| 08/07/2018 | 885 | 41.9026 | -83.2439 | 41.8984 | -83.2394 | 9:45 | 10 | 7.01 | 7.01 | 24.9 | 1.20 | 0.40 |
| 08/07/2018 | 877 | 41.9060 | -83.2669 | 41.9091 | -83.2607 | 11:00 | 10 | 7.01 | 7.31 | 24.5 | 1.38 | 0.40 |
| 08/07/2018 | 886 | 41.8665 | -83.2457 | 41.8688 | -83.2388 | 12:56 | 10 | 8.23 | 8.53 | 25.2 | 1.08 | 0.40 |
| 08/08/2018 | 872 | 41.8269 | -83.3274 | 41.8298 | -83.3210 | 9:09 | 10 | 6.40 | 6.40 | 24.4 | 1.33 | 0.40 |
| 08/08/2018 | 859 | 41.8192 | -83.3881 | 41.8195 | -83.3808 | 11:14 | 10 | 5.18 | 5.49 | 24.7 | 1.12 | 0.40 |
| 08/08/2018 | 855 | 41.7818 | -83.4227 | 41.7782 | -83.4170 | 13:44 | 10 | 4.27 | 4.57 | 25.3 | 0.92 | 0.40 |

Table 2.4.3. Average 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 1.25 inch screen.

| Common Name | Age Group | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| BROOK SILVERSIDE | All | 0 | 0 | 8.1 | 0 | 0 |
| EMERALD SHINER | All | 2.1 | 0 | 0 | 0 | 7.2 |
| FRESHWATER DRUM | Age-0 | 29.4 | 6.9 | 6.3 | 0 | 45.6 |
| GIZZARD SHAD | Age-0 | 55.4 | 2.7 | 11.4 | 730.9 | 259.4 |
| JOHNNY DARTER | All | 0 | 0 | 0 | 0 | 0.3 |
| LOGPERCH | All | 1.9 | 14.8 | 3.1 | 4.4 | 2.3 |
| MIMIC SHINER | All | 5.3 | 617.9 | 170.6 | 120.2 | 40.1 |
| RAINBOW SMELT | Age-0 | 0.3 | 2.7 | 0 | 2.2 | 0 |
| ROCK BASS | Age-0 | 0 | 0 | 0.2 | 0 | 0.5 |
| ROUND GOBY | All | 43.4 | 135.8 | 19.2 | 41.4 | 58.6 |
| SILVER CHUB | All | 0 | 11.3 | 0.6 | 3.4 | 5.9 |
| SMALLMOUTH BASS | Age-0 | 5.4 | 0.3 | 1.9 | 0 | 3.2 |
| SPOTTAIL SHINER | All | 54.2 | 18.8 | 26.6 | 2.2 | 6.3 |
| TROUT-PERCH | All | 25.6 | 16.8 | 68.8 | 62.1 | 290.4 |
| TUBENOSE GOBY | All | 0 | 0 | 1.9 | 2.2 | 1.7 |
| WALLEYE | Age-0 | 0.6 | 4.8 | 3 | 16.6 | 50.3 |
| WHITE BASS | Age-0 | 1.2 | 7 | 8.4 | 101.8 | 48.2 |
| WHITE PERCH | Age-0 | 715.5 | 783.2 | 448.5 | 1896.4 | 8100 |
| WHITE SUCKER | Age-0 | 0.3 | 0 | 0 | 0 | 0 |
| YELLOW PERCH | Age-0 | 129.5 | 335.8 | 424.4 | 331.6 | 1683 |
| GRAND TOTAL | - | 1070.1 | 1958.8 | 1203.0 | 3315.4 | 10603.0 |

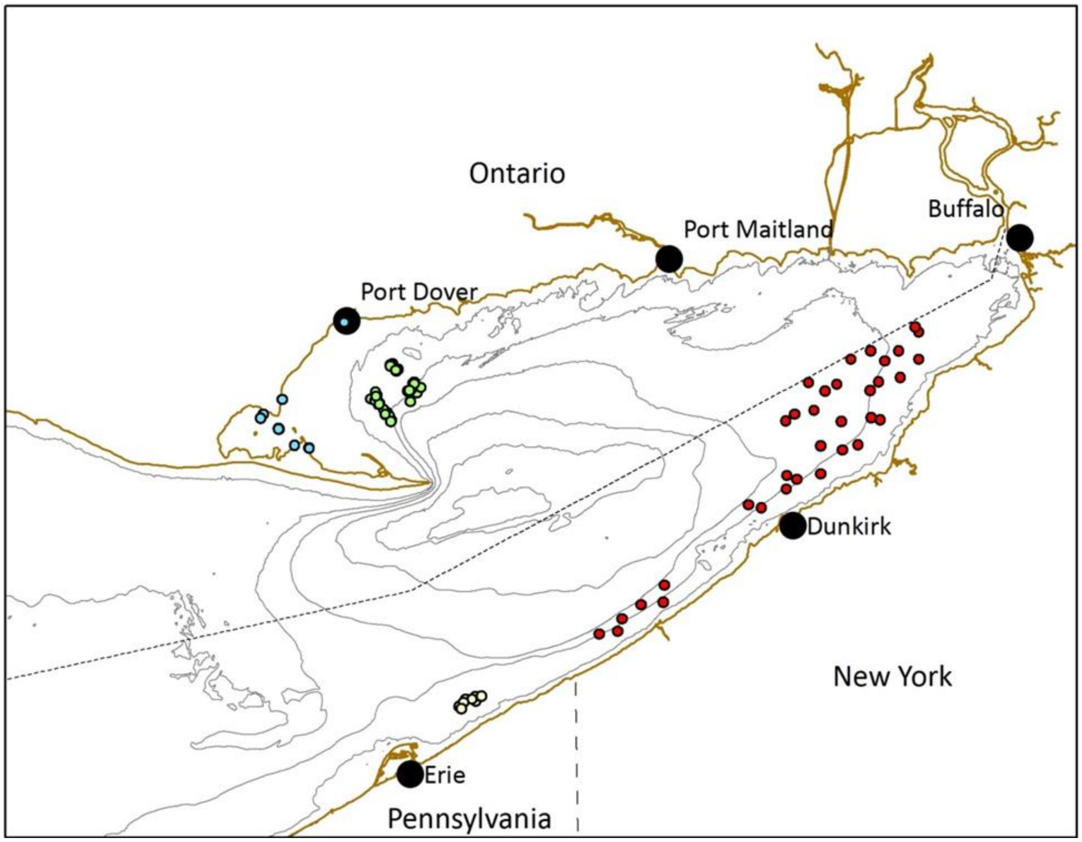


Figure 2.2.1 Locations sampled with standard index bottom trawls by Ontario (OMNRF), New York (NYSDEC) and Pennsylvania (PFBC) to assess forage fish abundance in eastern Lake Erie during 2018.

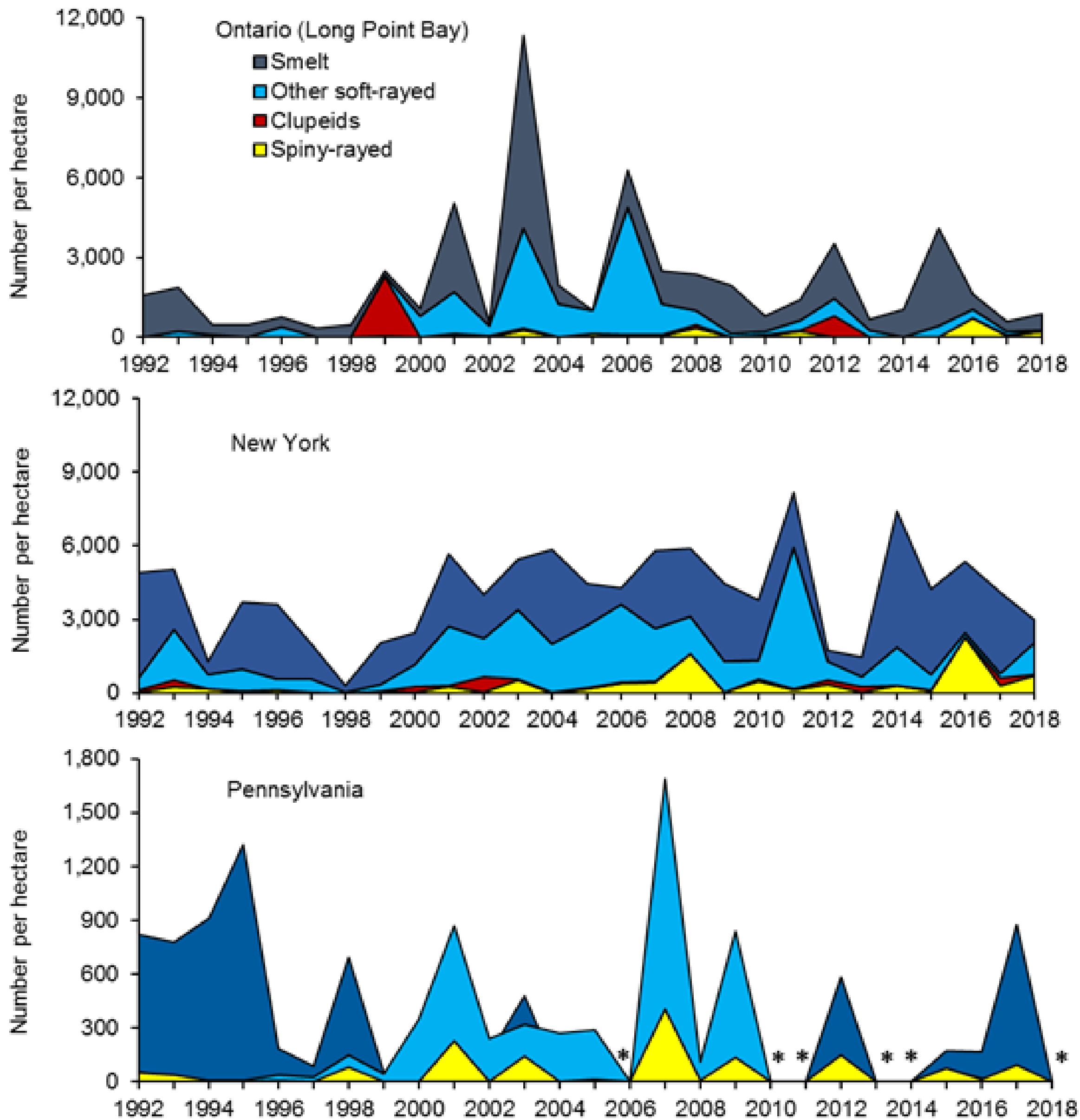


Figure 2.2.2 Mean density of prey fish (number per hectare) by functional group in the Ontario, New York and Pennsylvania waters of the eastern basin, Lake Erie, 1992-2018. Note that the y-axis values are lower for Pennsylvania. Asterix (*) indicate years in which agencies were not able to sample.

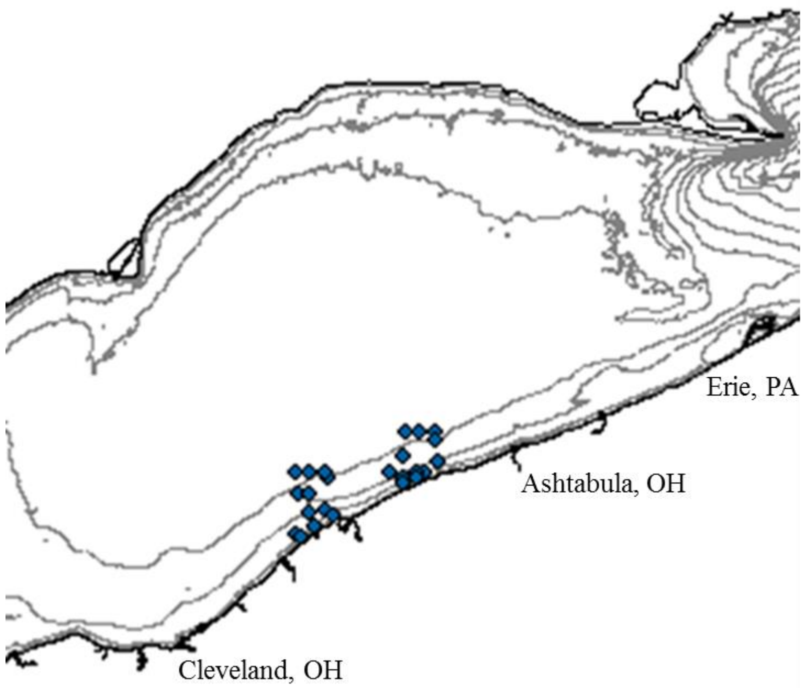


Figure 2.3.1 Locations sampled with index bottom trawls to assess forage fish abundance in the central basin, Lake Erie during 2018.

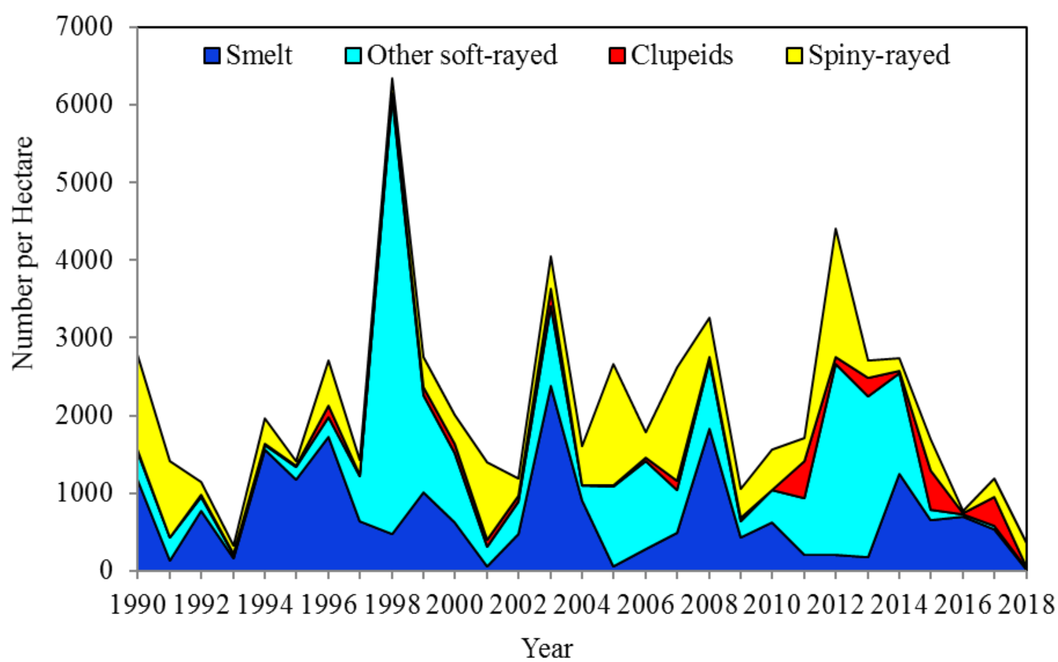


Figure 2.3.2 Mean density of prey fish (number per hectare) by functional group in the Ohio waters of the central basin, Lake Erie, 1990-2018.

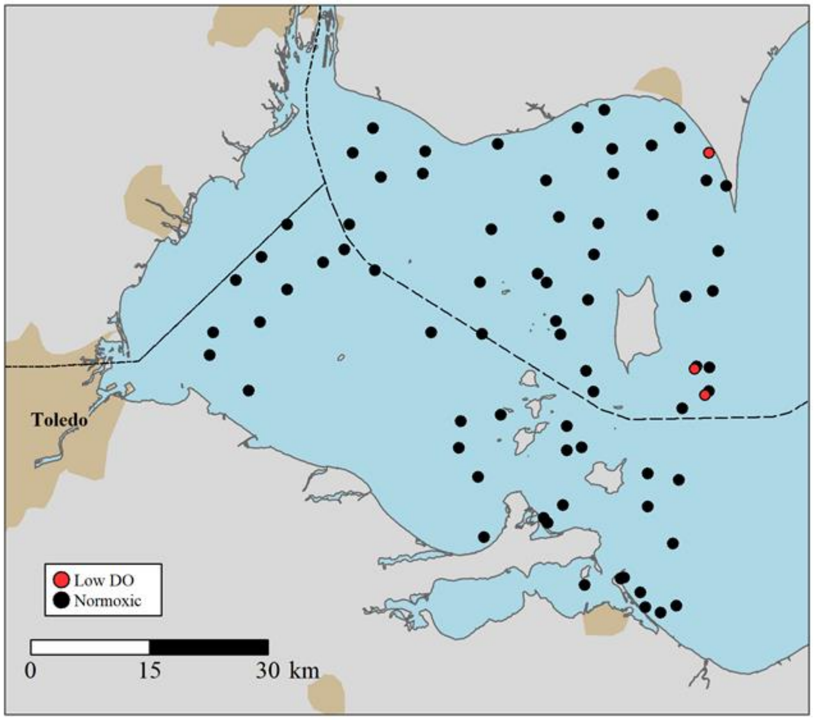


Figure 2.4.1. Trawl locations for the western basin interagency bottom trawl survey, August 2018. Low dissolved oxygen sites (< 2.0 mg/L; red) were removed from forage summaries.

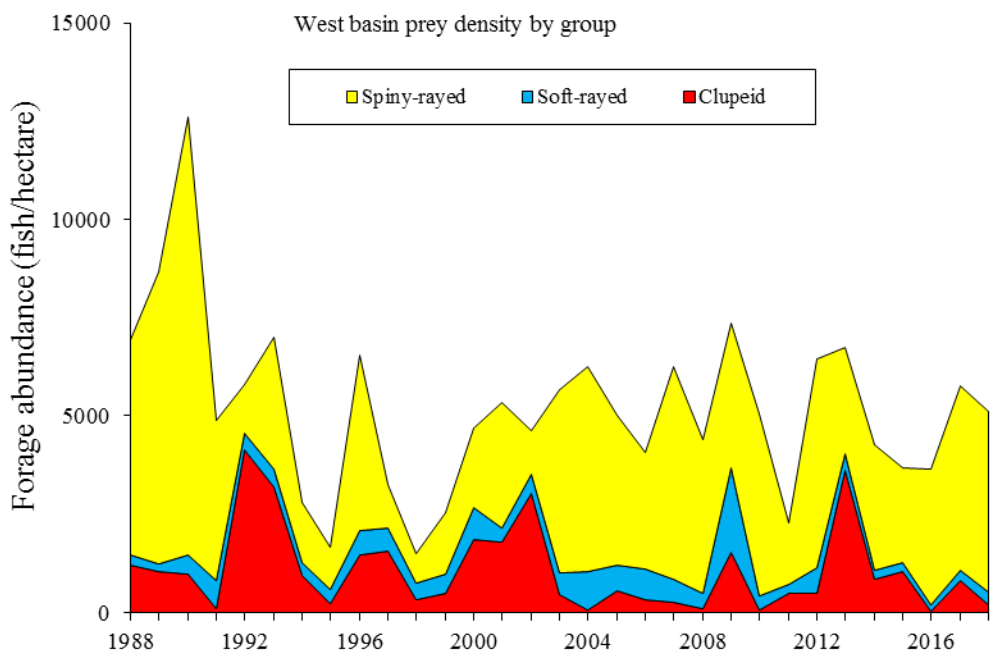


Figure 2.4.2. Mean density (number per hectare) of prey fish by functional group in western Lake Erie, August 1988-2018.

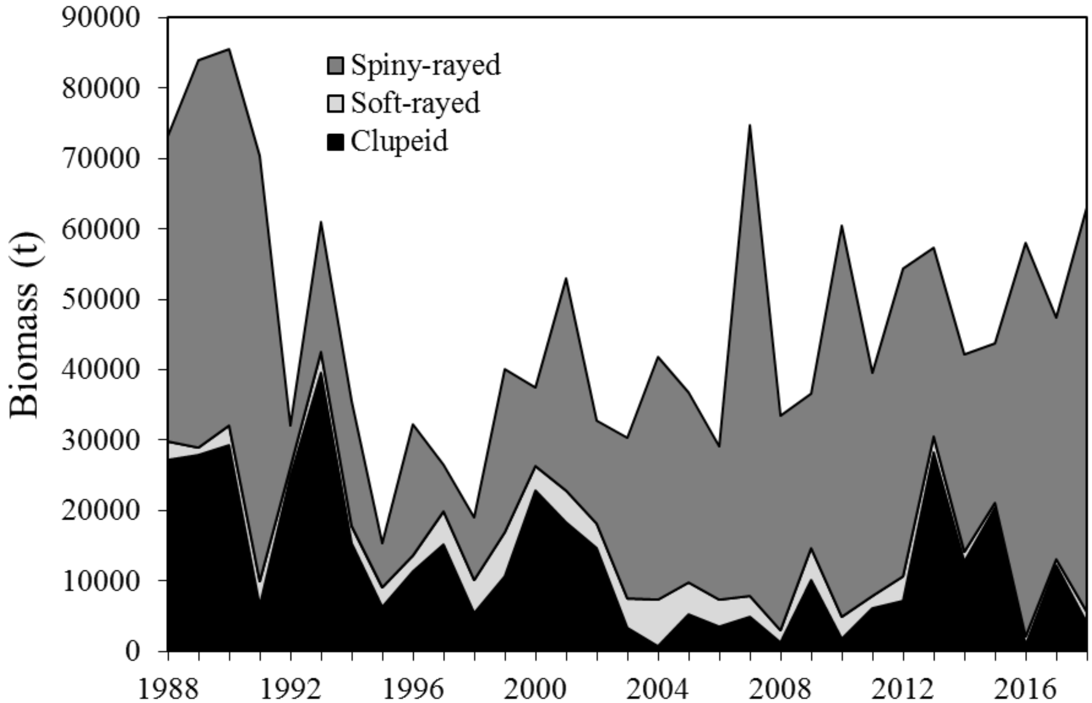


Figure 2.4.3. Mean biomass (tonnes) of prey fish by functional group in western Lake Erie, August 1988-2018.

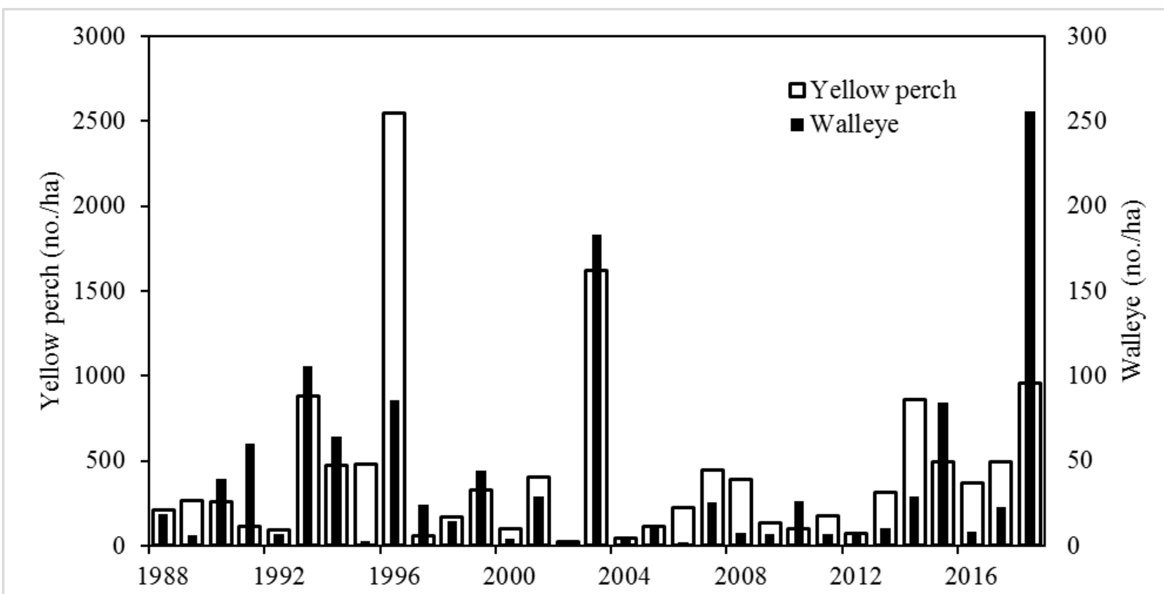


Figure 2.4.4. Density of age-0 Yellow Perch and Walleye in the western basin of Lake Erie, August 1988-2018.

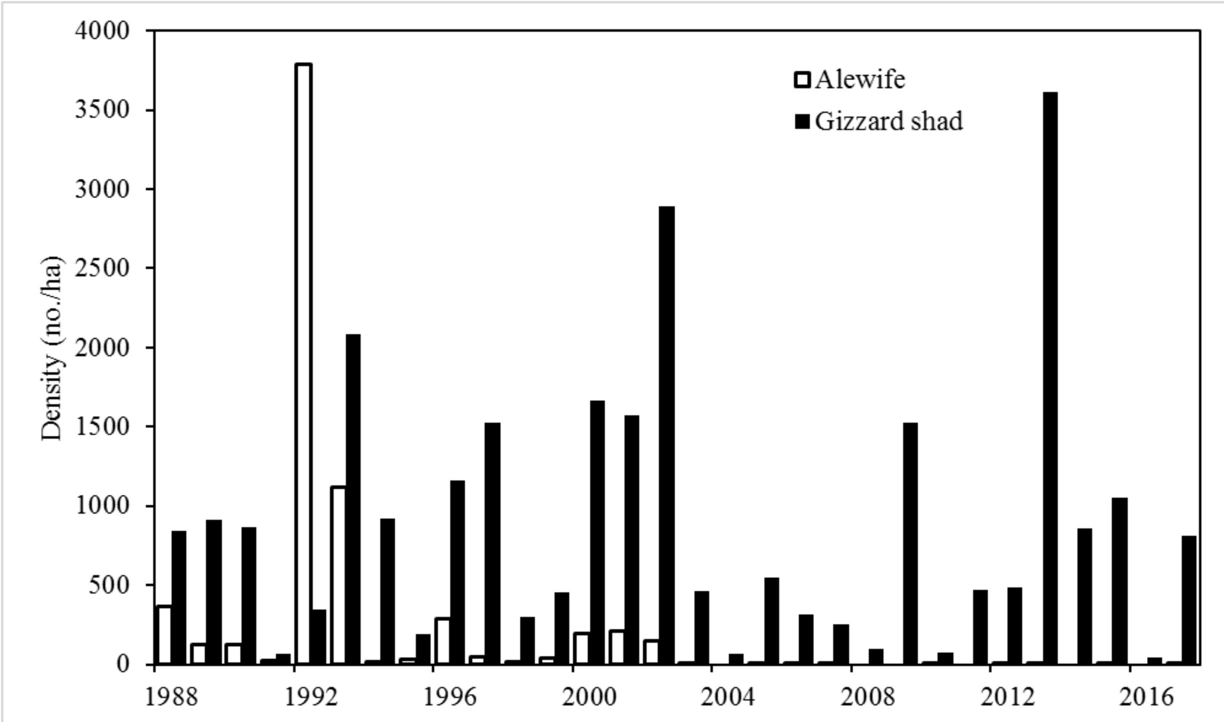


Figure 2.4.5 Density of age-0 Alewife and Gizzard Shad in the western basin of Lake Erie, August 1988-2018.

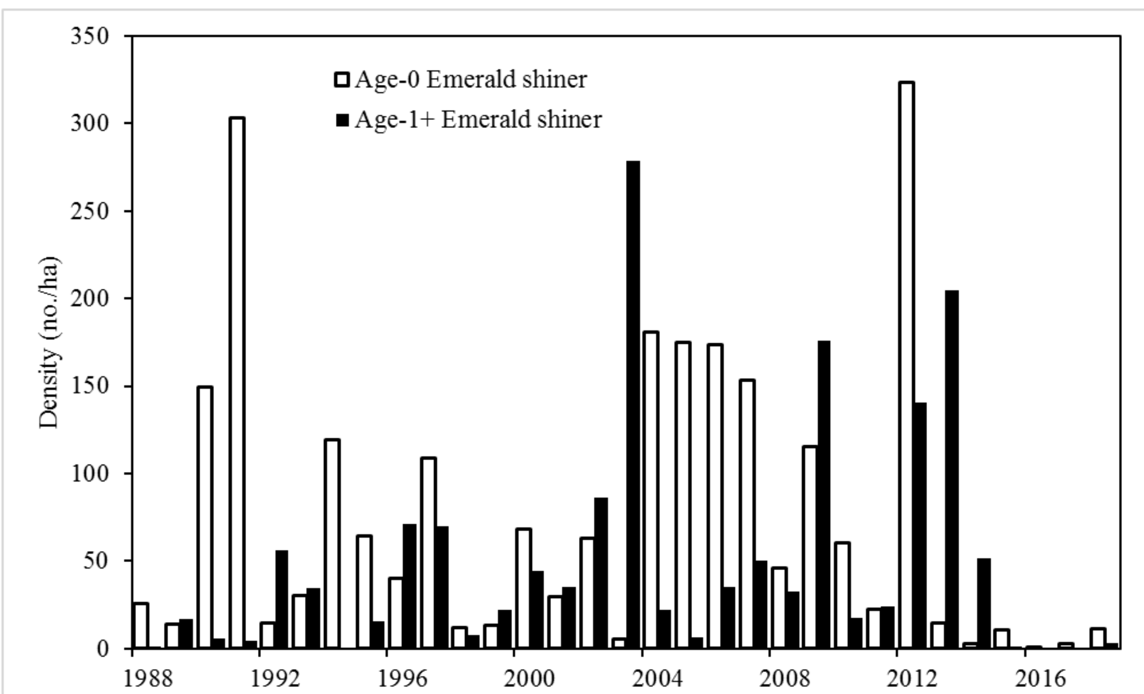


Figure 2.4.6. Density of age-0 and age-1+ Emerald Shiners in the western basin of Lake Erie, August 1988-2018.

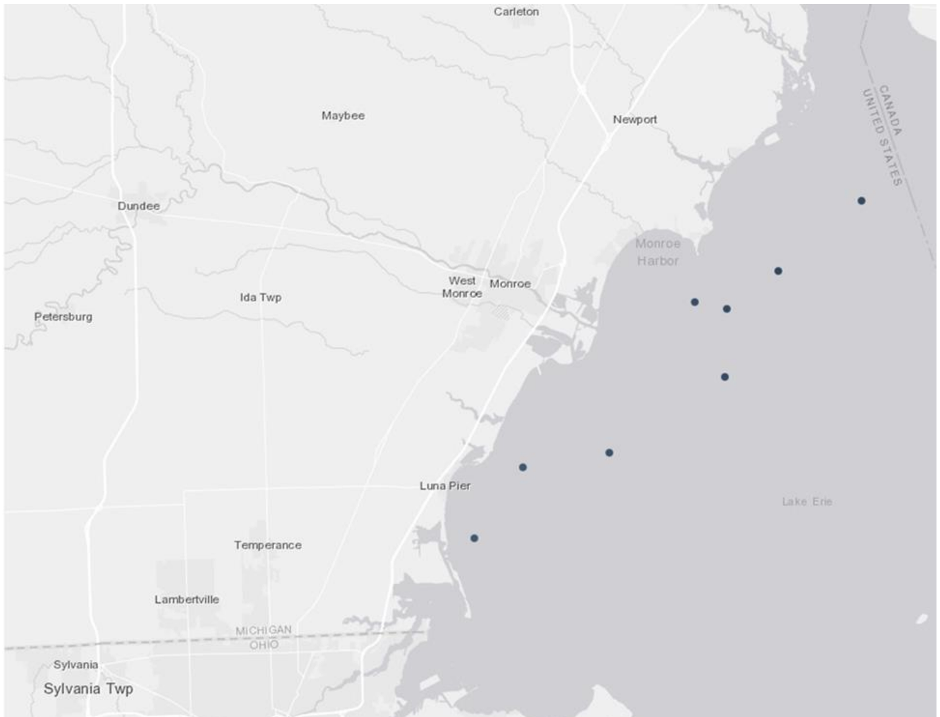


Figure 2.4.7. Map of Michigan waters of Lake Erie. The start of each trawl is indicated by a black dot.

**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 GLFC's Great Lakes Hydroacoustic Standard Operating Procedures where possible/feasible.**

### 3.1 East Basin Hydroacoustic Survey (C .May)

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). Companion mid-water trawls have been completed by NYDEC in the past but due to vessel issues, those data have not been collected since 2007. However, when meta-hypolimnion trawling was conducted in the past, yearling and older Rainbow Smelt made up greater than 90% of catches of fish of their acoustic target strength.

**Results**

Only Ontario waters were sampled in 2018 due to cross-border travel restrictions. Ten transects were completed, with a basin-wide average density of 642 fish/ha, representing a low density of forage fish in the east basin since 2007 (range=615-11936 fish/ha, median=3327 fish/ha; Figure 3.1.1). Nowhere was smelt density greater than 10,000 fish/ha (Figure 3.1.2).

### 3.2 Central Basin Hydroacoustic Survey (P. Kočovský and 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 central Lake Erie since 2004. The 2018 central basin hydroacoustic survey was planned according to the protocol and sample design established at the hydroacoustic workshop held in Port Dover, Ontario in December 2003 (Forage Task Group 2005). That 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 ODNR-DOW R/V *Grandon*. In 2018, the R/V *Muskie*, which has been the primary hydroacoustic vessel for past surveys, was not available. To maximize the amount of hydroacoustic data collected, the R/V *Grandon*, which typically conducts both hydroacoustic and midwater trawl sampling, collected only hydroacoustic data on the same transects as the R/V *Keenosay*. 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 were collected with a 122-kHz, 7.6-degree, split-beam transducer BioSonics DTX® echosounder and BioSonics Visual Acquisition (release 6.0) software. The transducer was mounted to the starboard hull on a movable bracket, roughly equidistant between the bow and stern, with the transducer face 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 *Grandon* were collected with a Garmin 17HVS. Global Positioning System coordinates were interfaced with the echosounder 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 7.1 software. Proportionate area backscattering coefficient was scaled by mean target strength calculated from 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. Two depth strata, epilimnetic and hypolimnetic, were established by examining distributions of single target strength by depth. 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 to monitor the quality of *in situ* single target data. If Nv for an interval-by-depth-stratum 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 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 from the same water stratum and from a similar total depth that was 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 *Grandon* 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-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**

Two cross-lake transects were sampled between 16 July and 20 July 2018 with hydroacoustics. The two remaining transects were not completed due to electrical problems with the R/V *Grandon.* All four transects were sampled with midwater trawls by the R/V *Keenosay* (Figure 3.2.1).

Thirty-six midwater trawls were completed during the survey. Rainbow Smelt comprised a very small proportion of the midwater trawl catch in 2018 (Table 3.2.1). Combined age groups of Rainbow Smelt comprised the majority of the catch in only 5 trawls. In 2017, Rainbow Smelt comprised the majority of the catch in 32 of 46 midwater trawls. The highest proportions of age-0 Rainbow Smelt were caught on transects 57600 in the center of the basin and 58100 in the eastern portion of the basin. Yearling-and-older Rainbow Smelt were caught primarily on the eastern most transect 58100.

Young-of-the-year Yellow Perch composed sizable portions of midwater trawl catches on all transects. Young-of-the-year Gizzard Shad, White Bass and White Perch also contributed to large proportions of trawl catch, primarily on the west transects 57600 and 57350. Emerald Shiner were caught on all transects in 2018, but the proportion in the catch remains extremely low. Other species caught in midwater trawls included White Bass (age-1+), Freshwater Drum (age-1+), Walleye Adult (age-1+), White Perch (age-1+), Yellow Perch (age-1+), Mimic Shiner (age-1+).

Acoustic target strength (TS) distributions showed differences in TS across depth strata. Highest acoustic densities occurred in the upper depth layers relative to the lower layer in both hydroacoustic transects (Table 3.2.2). In previous years, age groups of Rainbow Smelt typically separate by depth with age-0 occupying the warmer upper layer and age-1+ smelt in the cooler lower layer. In 2018, this held true for the west transect, 57600, but age-0 Rainbow Smelt were generally mixed above and below the thermocline on transect 57850. Most of the other species caught in midwater trawls were located in the upper layer.

Spatial distribution across transects varied by species and age group. Young-of-the-year Yellow Perch and Rainbow Smelt tended to be evenly distributed along both transects (Figure 3.2.2; 3.2.3). The highest densities of age-1+ Rainbow Smelt were in the center and southern ends of the basin.

Hydroacoustic 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). In 2018 only 33 Emerald Shiner were captured in 32 midwater trawls. Young-of-the-year and age-1+ Rainbow Smelt densities also decreased for the second year in a row and were the lowest in the time series.

Temperature and dissolved oxygen profiles collected concurrently with midwater trawls found one area of low oxygen near the center of transect 57350. 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 tended to be deeper on the north end of transects compared to the south end (Figure 3.2.6). 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 2018 there was a distinct lack of forage fish encountered in the central basin survey relative to previous years. This was consistent in both the hydroacoustic and midwater trawl portions of the survey. Using the two central transects in 2018, there were fewer single targets encountered in the upper layers in 2018 (mean=30) compared to 2017 (mean=119) per 500 m interval. Midwater trawls on the two transects showed a similar trend with a total catch of 3,178 fish in 2018, and 16,808 caught in 2017. The low forage densities in 2018 could be attributed to large cohorts of Walleye that were produced in the previous years. A similar situation in forage density occurred in the early 1990’s, after several large cohorts of Walleye in the late 1980’s.

In 2017 and again in 2018, there was a high proportion of age-0 Gizzard Shad, White Bass, and White Perch caught in midwater trawls relative to previous years. The high proportion of these “other” species is most likely due to the timing of the 2018 hydroacoustic survey and the low densities of Rainbow Smelt. Central basin hydroacoustic surveys are scheduled based on the timing of the new moon in July and are usually run during the days before and after the peak of the phase to take advantage of darker nighttime periods (Parker-Stetter et al. 2009). Typically, when hydroacoustic surveys are run later in July, age-0 Gizzard Shad, Emerald Shiner, White Bass, and White Perch will have grown enough to be recruited to midwater trawls and hydroacoustic sonar. Young-of-the-year Gizzard Shad, or the combination of age-0 Gizzard Shad, White Bass and White Perch were the highest proportion of the catch in eight midwater trawls, most trawls on western transects (57350, 57600).

A late July hydroacoustic survey would normally include catches of age-0 Emerald Shiner in addition to the normal contribution from age-1+ Emerald Shiner. This was not the case in 2017, or 2018. In 2017, only 15 age-0 and 32 age-1+ Emerald Shiner were captured in midwater trawls. In 2018, there were 17 age-0 and 16 age-1+ Emerald Shiner captured in midwater trawls. While Emerald Shiners are still present in the survey, their abundance remains at extremely low levels for both age groups.

In contrast to the recruitment of age-0 Gizzard Shad, White Bass, and White Perch, age-0 Yellow Perch are routinely caught during hydroacoustic surveys regardless of the timing of the new moon phase in July. The proportion of age-0 Yellow Perch in midwater trawls was relatively high in 2018 relative to previous years. The highest proportions of Yellow Perch were located on central and eastern transects and were uniformly distributed along the transects.

In June of 2017 we initiated analysis of the design and conduct of the central basin hydroacoustics program to address the questions discussed in previous reports to the Lake Erie Committee (Forage Task Group 2017). The principal objective is to better define what are relevant sampling strata for key forage species based on the last 10 years of trawl data from the R/V *Keenosay*, R/V *Musky II,* and R/V *Grandon*. Preliminary analyses have shown some basin wide trends in species location. We are proceeding with more rigorous analysis to try to quantify habitat boundaries (e. g. nearshore vs. offshore habitat). Results of the analysis will be discussed at future Forage Task Group meetings, and recommendations to improve the central basin survey will presented to the Lake Erie Committee.

### 3.3 West Basin Acoustic Survey (M. DuFour)

Since 2004, 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 been conducted in conjunction with acoustic data collection since 2006.

**Methods**

Two fixed cross basin transects were successfully sampled in 2018. Surveying took place in July 2018 with transect 2 on 12-13 July and transect 3 on 18-19 July. Transect 1 was not sampled due to inclement weather. All transects were surveyed using a single, downward-facing, 6.1-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 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 9.0 using a modified process developed by the Ohio Division of Wildlife Inland Fisheries Research Unit. Target strength range was estimated using Love's dorsal aspect equation (Love 1971):

Total length = 10 ((Target Strength + 26.1)/19.1) * 1000

Biomass estimates were based on average target length as determined by the above equation.

**Results**

In 2018, two cross-basin transects (approximately 100 km in total) were surveyed July 12-19. Average forage fish densities were highest on the middle transect (7,300 fish/ha), with a consistent distribution peaking in the northern portion of the transect. Average densities were lowest on the eastern transect (5,776 fish/ha), but variable with high concentrations of forage fish on the southern and northern edges of the transects (Figure 3.3.1). Average western basin forage fish densities (6,435 fish/ha) were slightly higher than 2017 densities (4,726 fish/ha), but below the time series average (15,143 fish/ha). Biomass (11.6 kg/ha) was higher than 2017 (8.3 kg/ha), although still less than the long-term mean (17.1 kg/ha; Figure 3.3.2).

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 2018.

| Transect | Trawl ID | Depth | Layer | Latittude | Longitude | Rainbow Smelt Age-0 | Rainbow Smelt Age-1+ | Yellow Perch Age-0 | Gizzard Shad Age-0 | White Bass Age-0 | White Perch Age-0 | other species |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 57350 | 4005 | 6 | 1 | 42.04450 | -82.19617 | 0.0% | 0.0% | 6.4% | 31.0% | 25.3% | 34.9% | 2.5% |
| 57350 | 4008 | 8 | 1 | 42.13500 | -82.24167 | 0.0% | 0.0% | 2.1% | 28.8% | 39.2% | 21.7% | 8.3% |
| 57350 | 4001 | 9 | 1 | 41.92767 | -82.15067 | 4.0% | 0.0% | 7.9% | 55.4% | 14.9% | 17.8% | 0.0% |
| 57350 | 4002 | 12 | 1 | 41.92700 | -82.17450 | 0.0% | 0.0% | 6.5% | 67.4% | 6.5% | 10.9% | 8.7% |
| 57350 | 4006 | 12 | 1 | 42.05717 | -82.22500 | 0.0% | 0.0% | 12.2% | 52.4% | 15.0% | 17.8% | 2.4% |
| 57350 | 4009 | 12 | 1 | 42.14717 | -82.25750 | 0.0% | 1.7% | 3.4% | 27.6% | 30.2% | 26.7% | 10.3% |
| 57350 | 4003 | 16 | 2 | 41.92317 | -82.15517 | 1.2% | 0.0% | 7.8% | 80.7% | 4.1% | 3.3% | 2.9% |
| 57350 | 4007 | 16 | 2 | 42.06467 | -82.24633 | 1.1% | 0.0% | 75.1% | 2.9% | 15.0% | 2.9% | 2.9% |
| 57350 | 4004 | 18 | 2 | 41.91767 | -82.17800 | 10.5% | 0.0% | 30.5% | 41.1% | 8.4% | 8.4% | 1.1% |
| | | | | | | | | | | | | |
| 57600 | 3001 | 5 | 1 | 42.07000 | -81.74417 | 12.9% | 0.0% | 78.2% | 2.0% | 0.0% | 6.9% | 0.0% |
| 57600 | 3005 | 5 | 1 | 42.20417 | -81.80367 | 0.0% | 0.0% | 5.5% | 19.2% | 61.6% | 11.0% | 2.7% |
| 57600 | 3008 | 10 | 1 | 42.25933 | -81.82183 | 38.9% | 1.8% | 12.4% | 0.0% | 18.6% | 4.4% | 23.9% |
| 57600 | 3002 | 12 | 1 | 42.05550 | -81.73800 | 10.3% | 0.0% | 13.8% | 72.4% | 3.4% | 0.0% | 0.0% |
| 57600 | 3006 | 12 | 1 | 42.18933 | -81.79567 | 0.0% | 0.0% | 44.8% | 0.0% | 37.9% | 6.9% | 10.3% |
| 57600 | 3009 | 13 | 1 | 42.24167 | -81.82267 | 34.2% | 1.4% | 2.7% | 0.0% | 35.6% | 0.0% | 26.0% |
| 57600 | 3003 | 16 | 2 | 42.07333 | -81.74483 | 44.6% | 0.0% | 19.6% | 32.1% | 0.0% | 3.6% | 0.0% |
| 57600 | 3007 | 16 | 2 | 42.20367 | -81.80633 | 0.0% | 0.0% | 13.9% | 25.0% | 44.4% | 8.3% | 8.3% |
| 57600 | 3004 | 20 | 2 | 42.05817 | -81.74300 | 2.0% | 24.0% | 12.0% | 56.0% | 2.0% | 4.0% | 0.0% |
| | | | | | | | | | | | | |
| 57850 | 2001 | 5 | 1 | 42.56467 | -81.46950 | 7.1% | 0.0% | 60.7% | 0.0% | 14.3% | 0.0% | 17.9% |
| 57850 | 2003 | 6 | 1 | 42.47433 | -81.43350 | 0.0% | 0.0% | 5.3% | 0.0% | 84.2% | 0.0% | 10.5% |
| 57850 | 2006 | 7 | 1 | 42.33500 | -81.38183 | 0.0% | 0.0% | 84.7% | 6.9% | 0.0% | 8.3% | 0.0% |
| 57850 | 2002 | 8 | 1 | 42.54783 | -81.46233 | 7.1% | 0.0% | 21.4% | 14.3% | 14.3% | 0.0% | 42.9% |
| 57850 | 2004 | 12 | 1 | 42.46067 | -81.41867 | 0.0% | 0.0% | 64.7% | 2.9% | 14.7% | 2.9% | 14.7% |
| 57850 | 2007 | 12 | 1 | 42.31850 | -81.37333 | 3.4% | 0.0% | 88.1% | 1.7% | 1.7% | 1.7% | 3.4% |
| 57850 | 2005 | 16 | 2 | 42.47633 | -81.41600 | 6.7% | 3.3% | 63.3% | 0.0% | 6.7% | 3.3% | 16.7% |
| 57850 | 2008 | 16 | 2 | 42.33050 | -81.36950 | 10.0% | 1.7% | 88.3% | 0.0% | 0.0% | 0.0% | 0.0% |
| 57850 | 2009 | 18 | 2 | 42.31333 | -81.36717 | 10.1% | 25.8% | 64.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | | | | | | | | |
| 58100 | 1001 | 5 | 1 | 42.62200 | -81.00800 | 0.0% | 0.0% | 14.3% | 19.0% | 57.1% | 0.0% | 9.5% |
| 58100 | 1003 | 5 | 1 | 42.54183 | -80.97417 | 11.5% | 0.0% | 19.2% | 15.4% | 53.8% | 0.0% | 0.0% |
| 58100 | 1006 | 8 | 1 | 42.38150 | -80.91600 | 0.0% | 0.0% | 97.9% | 0.0% | 0.0% | 0.0% | 2.1% |
| 58100 | 1002 | 9 | 1 | 42.60733 | -81.00117 | 46.7% | 0.0% | 26.7% | 0.0% | 0.0% | 0.0% | 26.7% |
| 58100 | 1004 | 12 | 1 | 42.51967 | -80.95833 | 38.3% | 0.0% | 53.2% | 0.0% | 2.1% | 0.0% | 6.4% |
| 58100 | 1007 | 12 | 1 | 42.37850 | -80.88767 | 0.0% | 0.0% | 76.9% | 0.0% | 0.0% | 0.0% | 23.1% |
| 58100 | 1008 | 15 | 2 | 42.39467 | -80.88317 | 0.3% | 98.7% | 0.3% | 0.0% | 0.0% | 0.0% | 0.6% |
| 58100 | 1005 | 16 | 2 | 42.50550 | -80.94817 | 0.0% | 0.0% | 81.8% | 0.0% | 0.0% | 0.0% | 18.2% |
| 58100 | 1009 | 18 | 2 | 42.37783 | -80.88667 | 16.0% | 60.0% | 24.0% | 0.0% | 0.0% | 0.0% | 0.0% |

Other species captured: White Bass (age-1+), Emerald Shiner (all aged), Freshwater Drum (age-1+), Walleye Adult (age-1+), White Perch (age-1+), Yellow Perch (age-1+), Mimic Shiner (age-1+).

Table 3.2.2. Density (number per hectare) of key species by age class and depth layer for hydroacoustic transects in central basin Lake Erie, July 2018. Transect numbers refer to Loran-TD lines. Depth layers were determined by differences in acoustic target strength (TS) across depth strata within each transect. Species were applied from midwater trawl catch by nearest distance within depth layer.

| | | 57600 | | 57850 | |
|---|---|---|---|---|---|
| Age | Species | Upper | Lower | Upper | Lower |
| Age-0 | Rainbow Smelt | 128.3 | 14.2 | 24.0 | 79.0 |
| Age-1+ | Rainbow Smelt | 0.5 | 81.5 | 0.0 | 170.5 |
| Age-0 | Yellow Perch | 209.2 | 45.3 | 715.8 | 537.7 |
| Age-0 | Gizzard Shad | 779.4 | 197.8 | 28.3 | 0.0 |
| Age-0 | White Bass | 92.6 | 10.7 | 82.6 | 4.7 |
| Age-0 | White Perch | 12.1 | 14.9 | 23.0 | 2.3 |
| | other species | 14.7 | 0.7 | 63.9 | 11.7 |

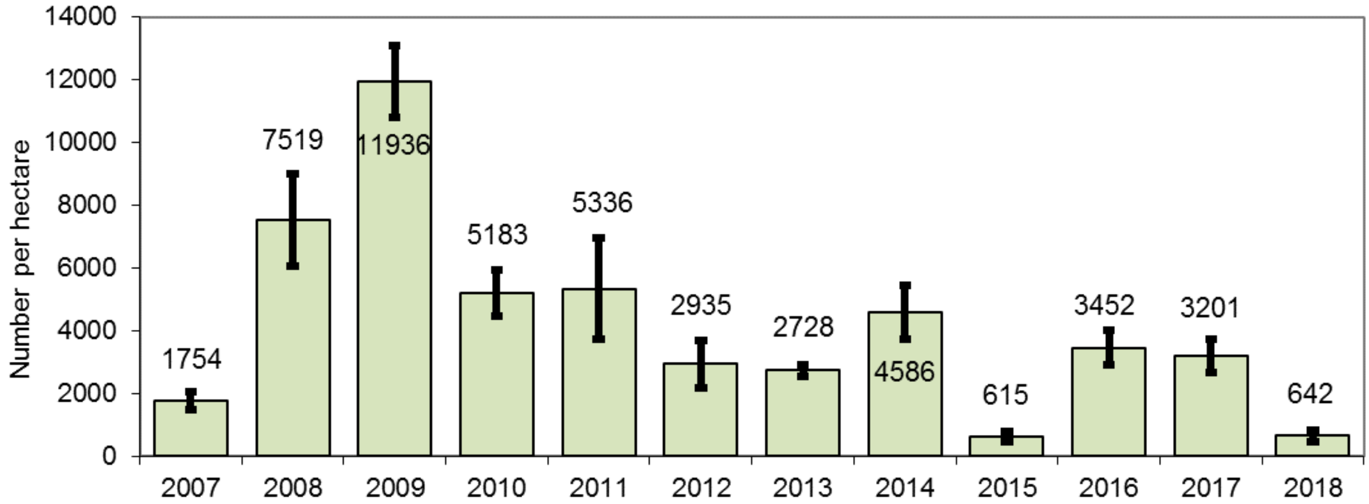


Figure 3.1.1. Mean density (fish per hectare) estimates of age-1+ Rainbow Smelt in coldwater habitat during the July east basin hydroacoustics survey, 2007-2018. Only four strata were sampled in 2014 and three in 2015. Only Ontario waters were sampled in 2018. Bars represent standard error.

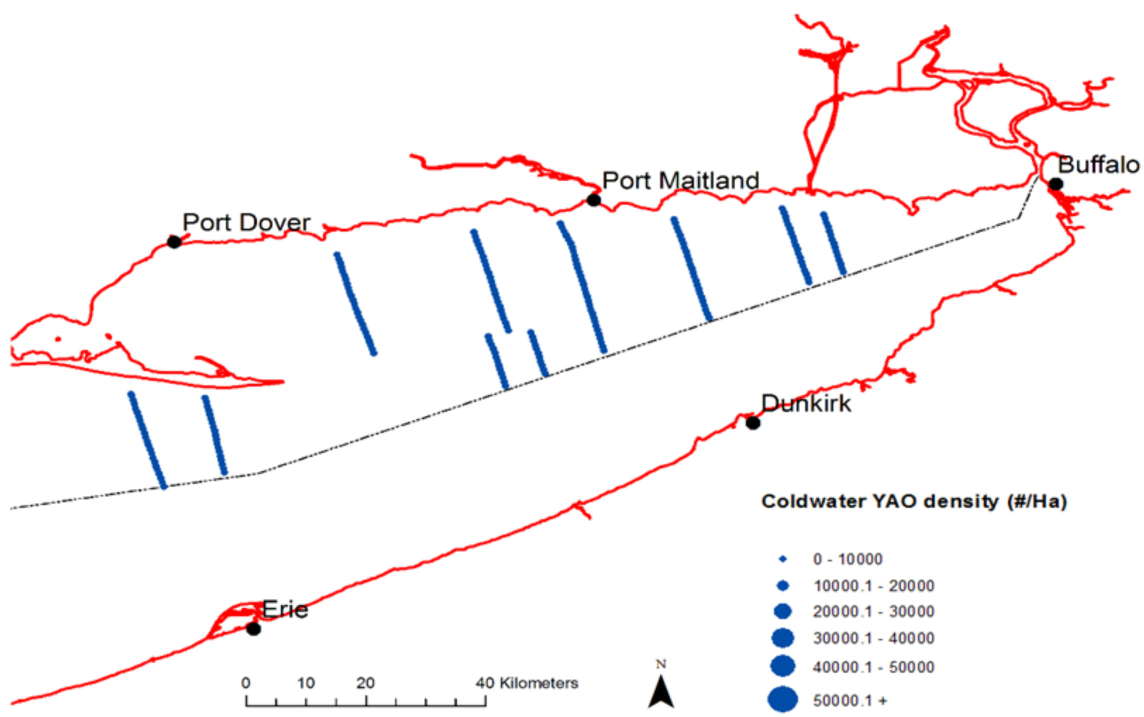


Figure 3.1.2. Density estimates of age-1+ Rainbow Smelt (fish per hectare) per 800 m interval along hydroacoustic transects in the eastern basin, Lake Erie in 2018. Only Ontario waters were sampled in 2018.

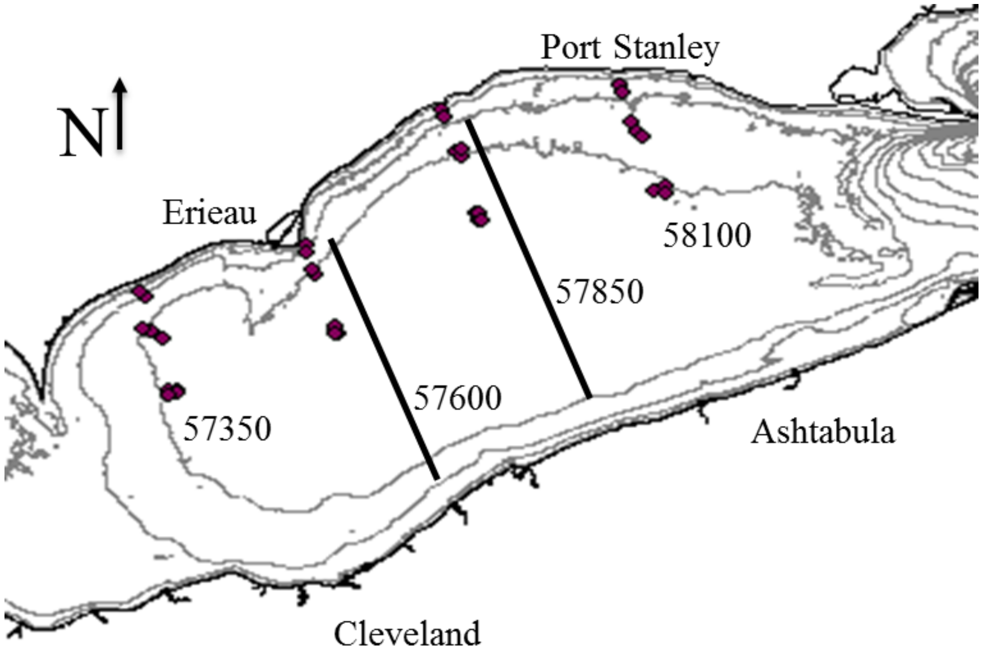


Figure 3.2.1 Hydroacoustic transects (solid lines) and midwater trawling stations (◆) in the central basin, Lake Erie, July 17-21, 2018. Transect numbers are Loran-TD lines.

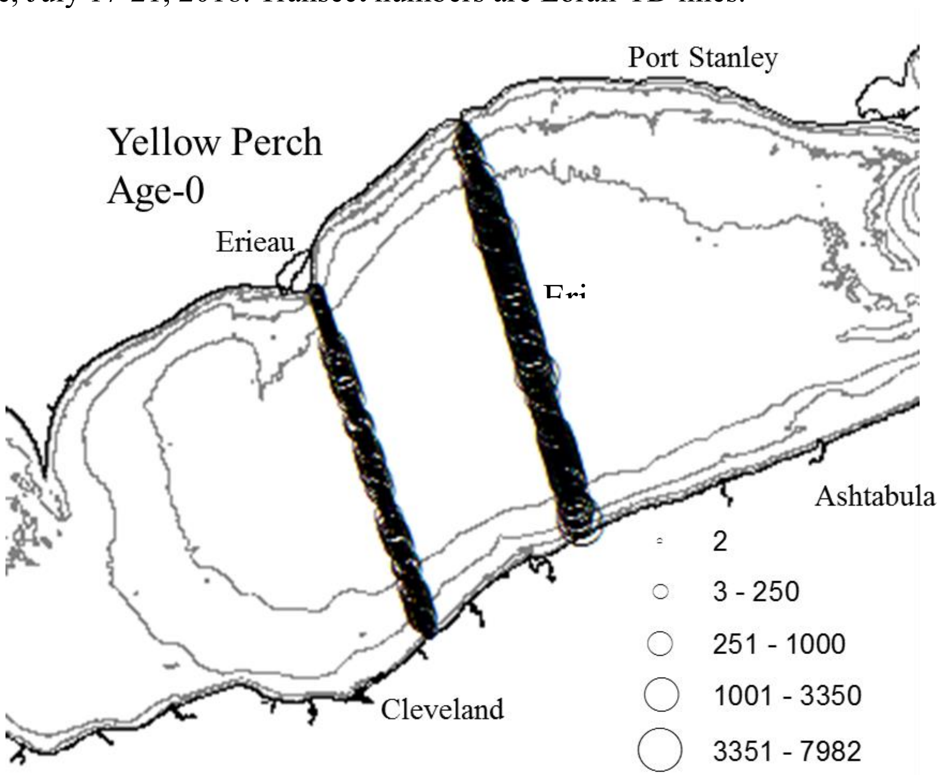


Figure 3.2.2. Density estimates of age-0 Yellow Perch (number per hectare) per distance interval along hydroacoustic transects in the central basin, Lake Erie. Distance intervals were 500 m segments to ensure adequate numbers of single targets for *in-situ* analysis. Transects are Loran-TD lines sampled in 2018.

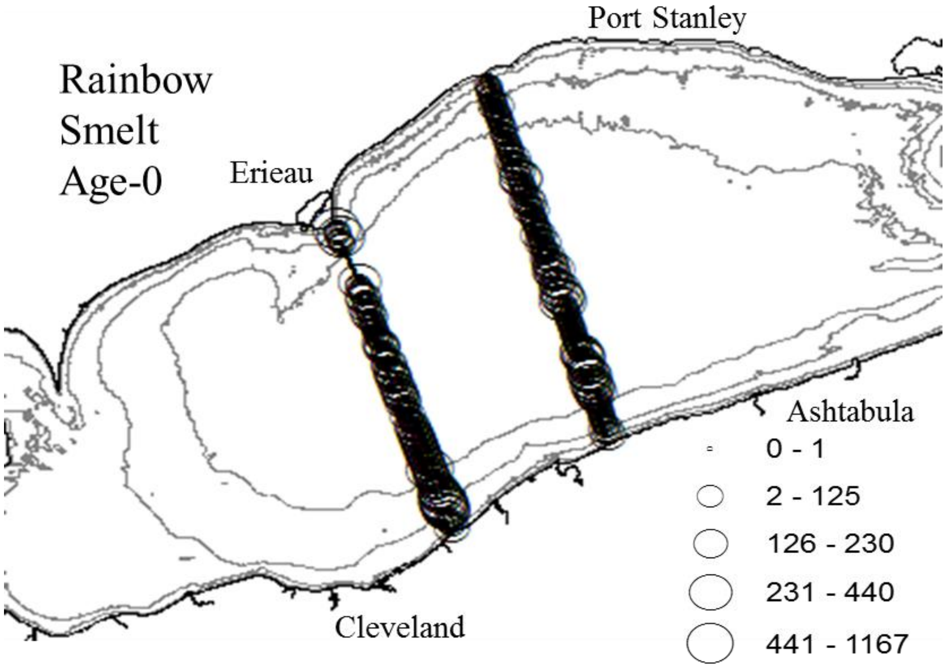


Figure 3.2.3. Density estimates of age-0 Rainbow Smelt (number per hectare) per distance interval along hydroacoustic transects in the central basin, Lake Erie. Distance intervals were 500 m segments to ensure adequate numbers of single targets for *in-situ* analysis. Transects are Loran-TD lines sampled in 2018

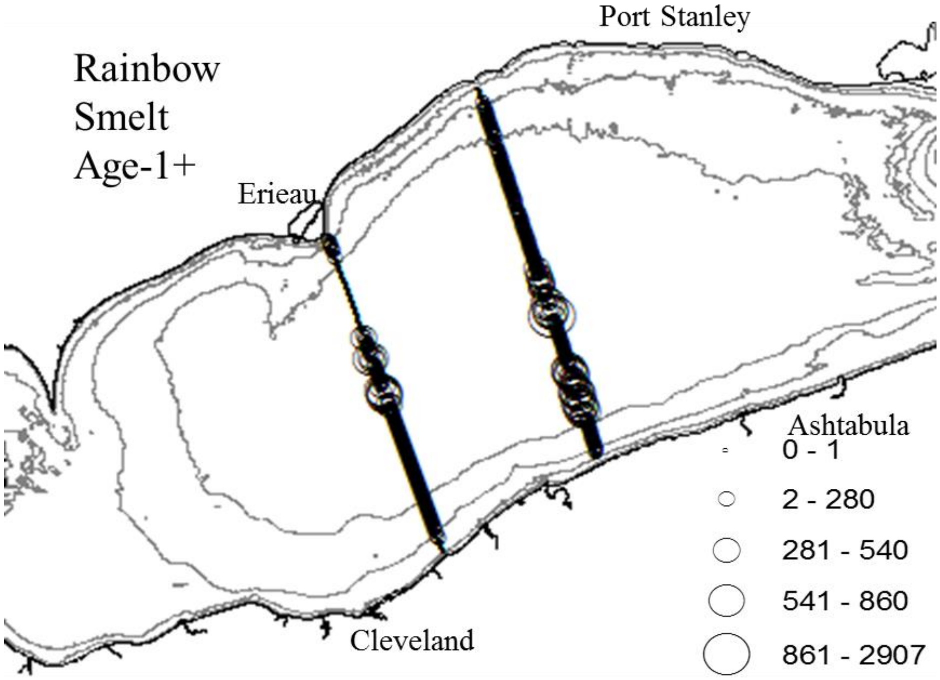


Figure 3.2.4. Density estimates of age-1+ Rainbow Smelt (number per hectare) per distance interval along hydroacoustic transects in the central basin, Lake Erie. Distance intervals were 500 m segments to ensure adequate numbers of single targets for *in-situ* analysis. Transects are Loran-TD lines sampled in 2018.

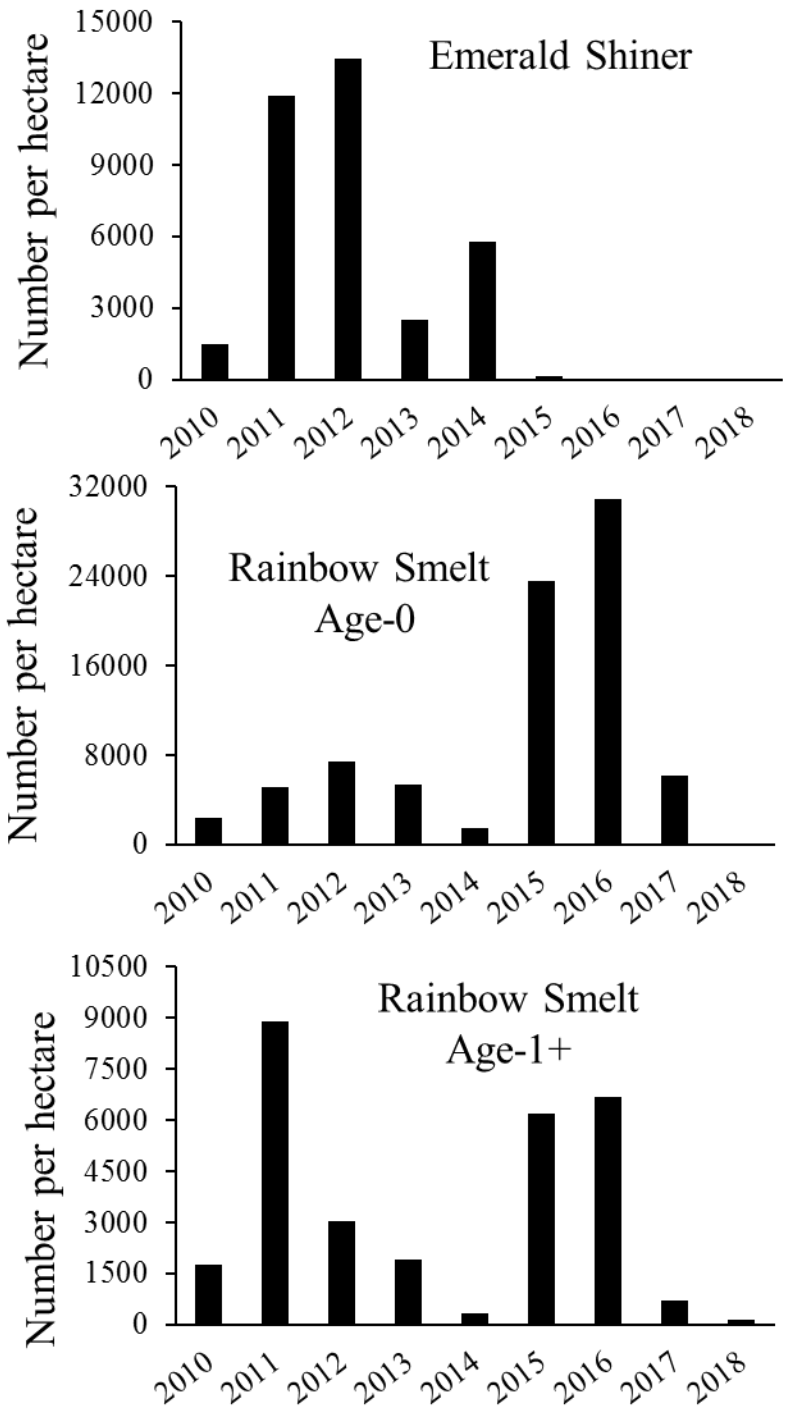


Figure 3.2.5. Mean density (number per hectare) estimates of pelagic forage fish during the July central basin, Lake Erie hydroacoustic survey, 2010-2018.

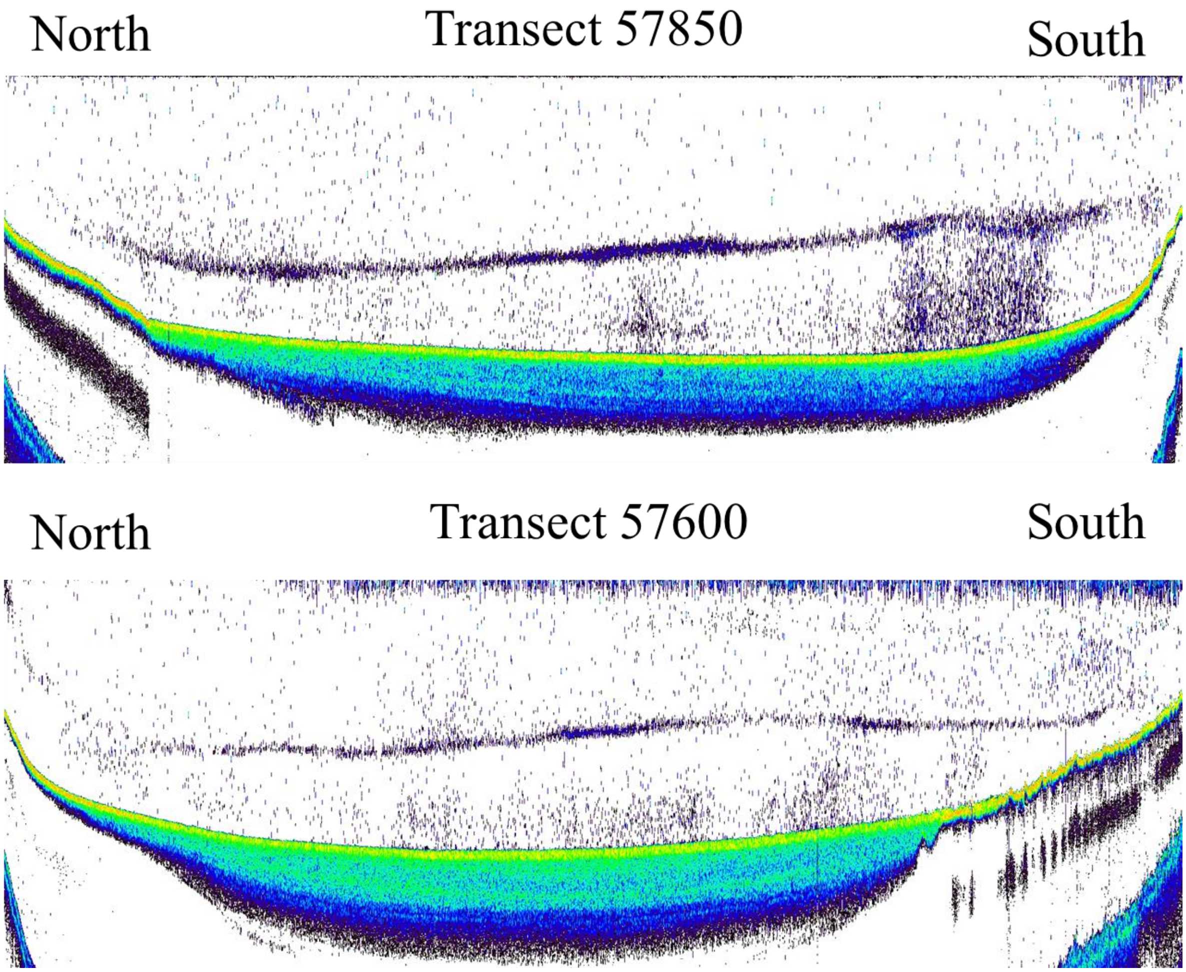


Figure 3.2.6. Echogram files generated from Echoview® software version 6.1 that show total back scattering (Sv) along transects run by the R/V *Grandon* in the central basin, 2018. Top panel is eastern transect, bottom panel is western transect.

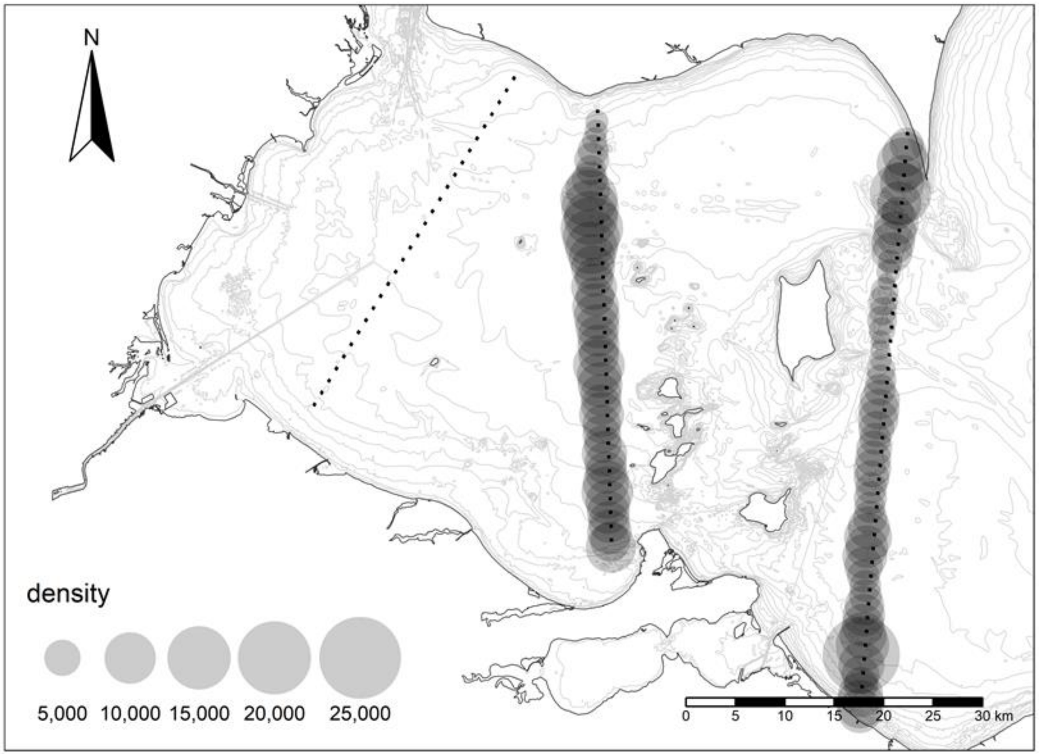


Figure 3.3.1. Acoustic survey transects and associated density (number per hectare) for the western basin of Lake Erie, 2018. Transect 1 was not sampled due to inclement weather.

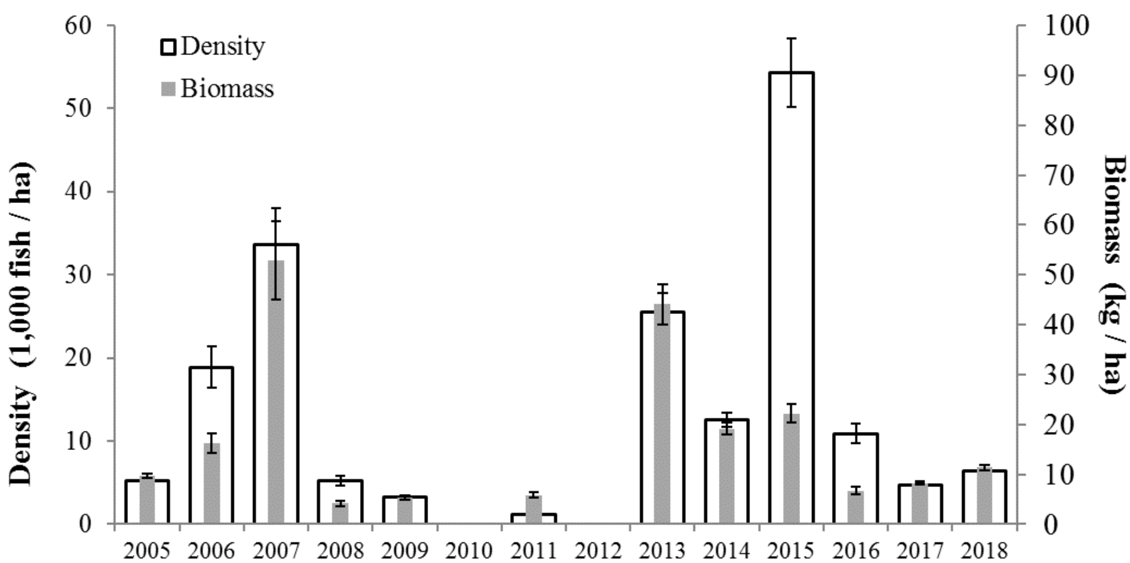


Figure 3.3.2. Mean density (number per hectare) and biomass (kilograms per hectare, solid grey bars) estimates from the western basin acoustic survey, 2005-2018. Estimates are for acoustic targets between -60dB and -38dB. Error bars are standard errors.

**Charge 4: Report on the use of forage fish and new invasive species in the diets of selected commercially or recreationally important Lake Erie predator fishes.**

**4.1 Eastern Basin** ( J. Markham)

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 2018, 296 Walleye stomachs were examined of which 83 (28%) contained food remains. Diets of angler-caught Walleye contained mostly Round Goby, Smelt, and White Perch. Smelt and Round Goby were the dominant walleye diet items by volume for angler-caught adult Walleye (Figure 4.1.1). The contribution by volume of identifiable species included five fish species: Round Goby (25%), Rainbow Smelt (25%), White Perch (15%), Stone Cat (13%, 1 individual, highly unusual occurance), and Yellow Perch (1%). Also of note was the presence of zooplankton in walleye stomachs (5% by volume) which is a rare occurrence but has been present for the past two years. The past four years of the survey were the only period in which Smelt did not dominate Walleye diets.

Seasonal diet information for Lake Trout is not available based on current sampling protocols. Diet information was limited to fish caught during August 2018 (N=289) in the interagency coldwater gill net assessment (CWA) surveys in the eastern basin of Lake Erie. Rainbow Smelt have traditionally been the main prey item for Lake Trout, comprising 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 appear to prey more on Round Goby.

In 2018, Round Goby and Rainbow Smelt were equally prevalent diet items for Lake Trout, occurring in 58% and 57% of the stomachs, respectively (Figure 4.1.2). It should be noted that Round Goby were much more numerically abundant in Lake Trout diets compared to Rainbow Smelt; some stomachs contained in excess of 50 Round Goby compared to a few adult smelt. Other fish species comprised 15% of the diets, which is the highest occurrence in the time series. Yellow perch comprised the majority of this group (14%); other species included Morone sp. (white perch, white bass; <1%), freshwater drum (<1%), and salmonids (<1%).

Similar to Lake Trout, the only diet information available for Burbot was collected during the CWA survey. Analysis of stomach contents (N=36) revealed a diet comprised mostly of fish. Burbot diets continue to be diverse, with five different identifiable fish species found in stomach samples. Round Goby was the dominant prey item, occurring in 69% of Burbot diet samples, followed by Rainbow Smelt (14%), Yellow Perch (11%), Gizzard Shad (6%) and White Perch (3%) (Figure 4.1.3). 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 two years. In 2018, age-1 and age-2 walleye were 0.9 and 0.7 inches below the long-term average length, respectively; age-1 walleye were at their smallest length-at-age in the 38-year time series (Robinson 2019). In general, age-0 and age-1 Yellow Perch have exhibited stable growth rates over the past ten years. In 2018, age-0 Yellow perch were at their time series average while age-1 fish were below average and their smallest length-at-age since 2005 (Markham and Robinson 2019).

Adult Walleye condition in the New York waters of Lake Erie has been trending down over the past decade. In 2018 the estimated weight of a 20-, 24- and 28-inch harvested Walleye was 2.4, 4.1 and 6.6 lbs., respectively, compared to long-term averages of 2.7, 4.8 and 7.6 lbs. (Figure 4.1.4). This may indicate a lack of suitable forage, especially Smelt.

Adult Lake Trout condition in the New York waters of Lake Erie has generally remained stable over the 19-year times series (Figure 4.1.5). Slight declines in condition were observed in 2018 at the estimated weights of 20, 24, and 28 inches; the 28-inch weight-at-age was the lowest in the time series. Lake Trout growth in Lake Erie continues to be among the highest in the Great Lakes.

### 4.2 Central Basin (J. Deller)

Diets of adult Walleye are collected from the central basin fall gill net survey in Ohio waters. Gizzard shad comprised 72% (by dry weight) of Walleye diets (Figure 4.2.1). Emerald Shiner normally contribute up to 30% of Walleye diets. Emerald Shiner was not present in Walleye diets examined in 2016. In 2018, Emerald Shiner comprised only 5% of Walleye diets with the remaining diet items being Rainbow Smelt (7%) and other fish (9%).

Round Goby continue to comprise large portions of Smallmouth Bass diets in the central basin. In 2018, Round Goby accounted for 77% of Smallmouth Bass diets by dry weight (Figure 4.2.2). This was the third year that Round Goby accounted for more than 75% of Smallmouth Bass diets in spite of declining Round Goby abundance.

## Growth

Growth rates of most age-0 forage species in 2018 were at or above long-term means. Mean length at age for Walleye from age-0 through age-3 was below long-term means. Mean length of age-0 Walleye was the lowest in the time series, most likely due to the exceptional cohort in 2018. Mean length of Yellow Perch for age-2 through age-7 is above long-term means and size at age has generally increased for those age groups over the last three years.

### 4.3 Western Basin (K. Keretz, C. Knight, Z. Slagle)

In 2018, adult Walleye diets (by frequency of occurrence; 61 stomachs, 48 prey items) taken from ODNR fall gillnet catches consisted of Gizzard Shad (58%), White Perch (2%), Yellow Perch (2%), and unidentifiable fish remains (38%) in the western basin. Yearling Walleye (38 stomachs, 21 prey items) relied on Gizzard Shad (48%), White Perch (14%), Emerald Shiner (5%), and unidentifiable fish remains (33%). All age-0 Walleye diets (n = 5) from the fall gillnet survey in 2018 were empty.

USGS collected stomachs from age-1+ Yellow Perch captured in bottom trawls from 41 sites throughout the western basin in September 2018. 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), dried in a Heratherm drying oven at 60° C until a constant mass was achieved, then weighed to the nearest 0.001 g. Fifty-six Yellow Perch stomachs were collected in September, twenty-five of which were empty. Analyses below are based on stomachs containing food.

Benthic macroinvertebrates and zooplankton were found most frequently in Yellow Perch diets in September (48% each; Figure 4.3.1). Specifically, the most common zooplankton consumed were Bythotrephes sp. (32%), Daphnia spp. (9%), Bosmina (5%) and Cyclopoid spp. (2%). Hexagenia spp. (23%)

and Gastropoda (9%) were the most frequently found benthic macroinvertebrates, with Amphipoda, Dreissenidae, Hirudinea, Ostracod, and Trichoptera spp. found at lower frequencies (2%). Fish prey occurrence was low when compared to benthic macroinvertebrates and zooplankton (13%; Figure 4.3.1). A Round Goby and a White Perch were identified in separate diets. The remaining 2 diets contained unidentifiable fish.

Based on mean percent dry weights, zooplankton (45%) and benthic macroinvertebrates (42%) contributed the most to Yellow Perch diets in September (Figure 4.3.2). The highest contributing benthic macroinvertebrates were Hexagenia spp. (27%) and Gastropoda (7%). All other macroinvertebrates contributed less than or equal to 3%. The zooplankton taxa Bythotrephes sp. contributed 44% while all other zooplankton taxa combined were less than 2% of the average individual's diets. Fish prey composed 12% of an individual's diet (Round Goby and White Perch were 3%, and unidentified fish prey was 6%).

**Growth**

Overall, mean length of age-0 sport fish in 2018 increased slightly compared to 2017 (Figure 4.3.3). Lengths of select age-0 species in 2018 include Walleye (123 mm), Yellow Perch (66 mm), White Bass (67 mm), White Perch (58 mm), and Smallmouth Bass (74 mm). Walleye were below the ten-year average (128 mm); Yellow Perch, White Perch, White Bass, and Smallmouth Bass were all near long-term averages (68 mm, 60 mm, 65 mm, and 74 mm respectively).

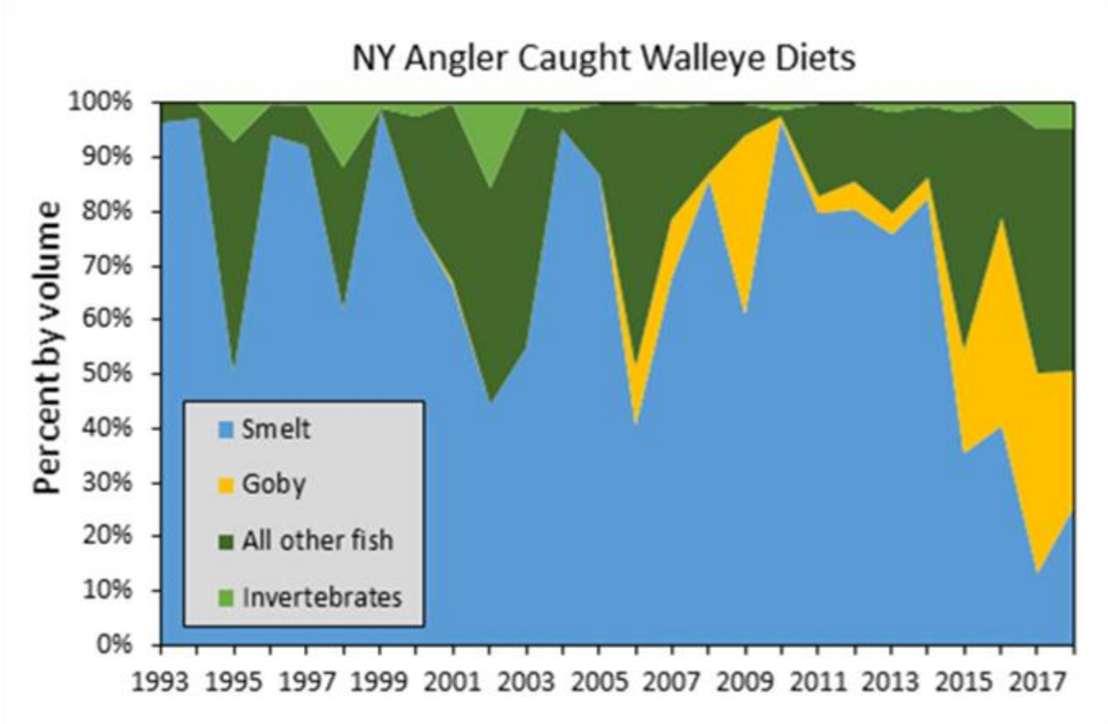


Figure 4.1.1. The percent contribution (by volume) of identifiable prey in stomachs of adult Walleye caught by summertime anglers in New York's portion of Lake Erie, 1993-2018.

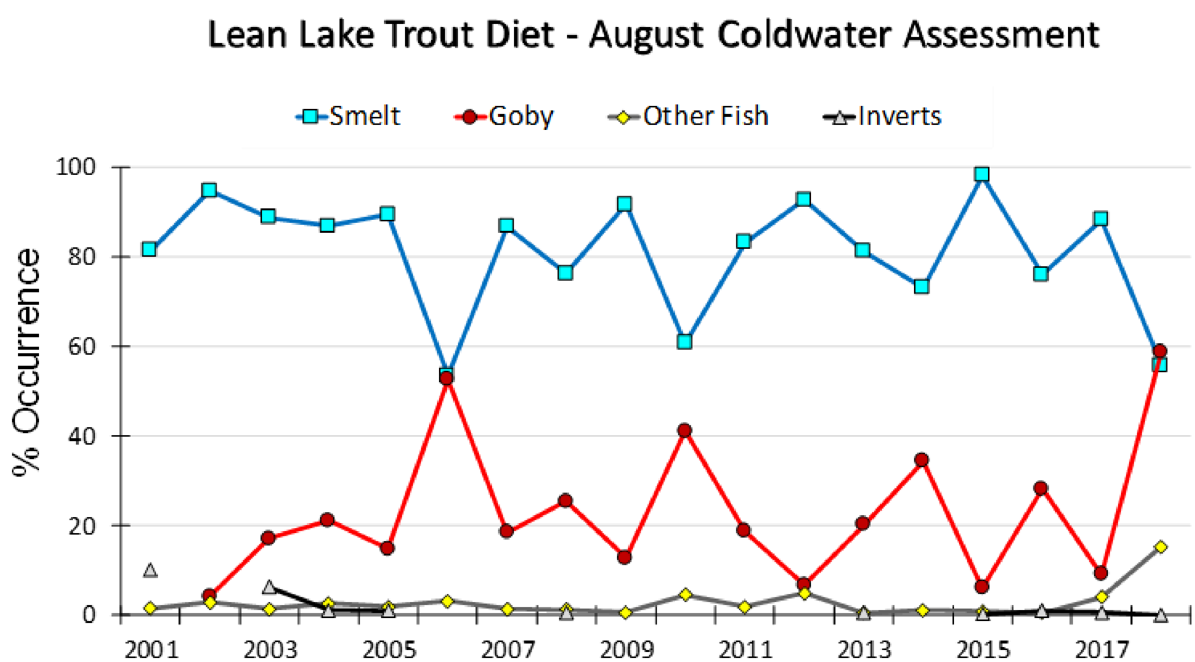


Figure 4.1.2. Percent occurrence of diet items from non-empty stomachs of Lean strain Lake Trout collected in eastern basin gill net assessments, August, 2001-2018.

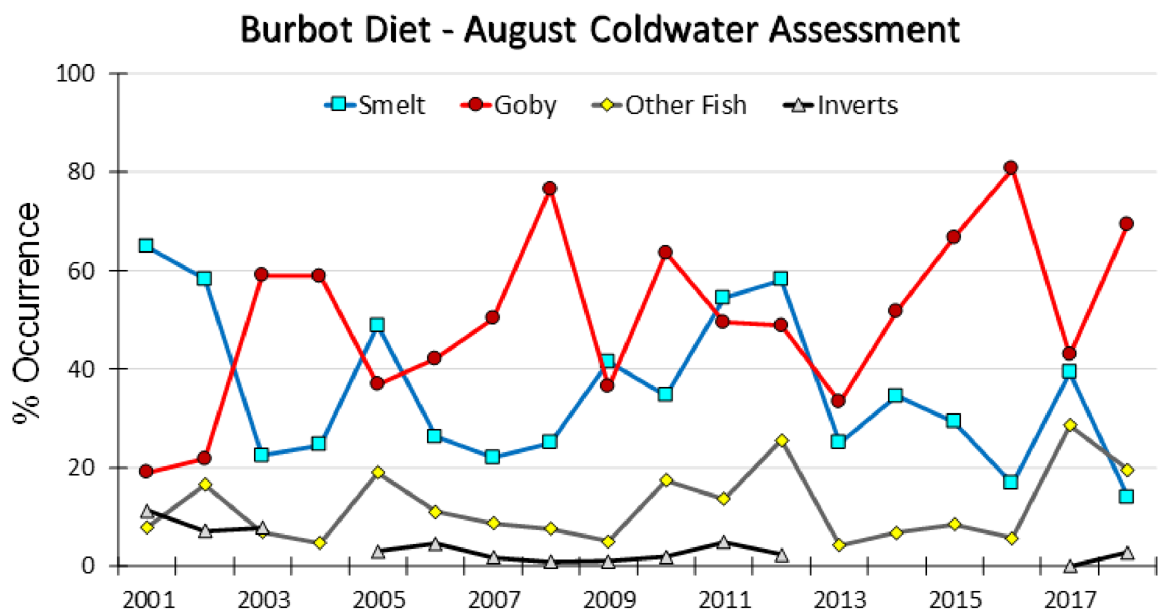


Figure 4.1.3. Percent occurrence of diet items from non-empty stomachs of Burbot collected in eastern basin gill net assessments, August, 2001-2018.

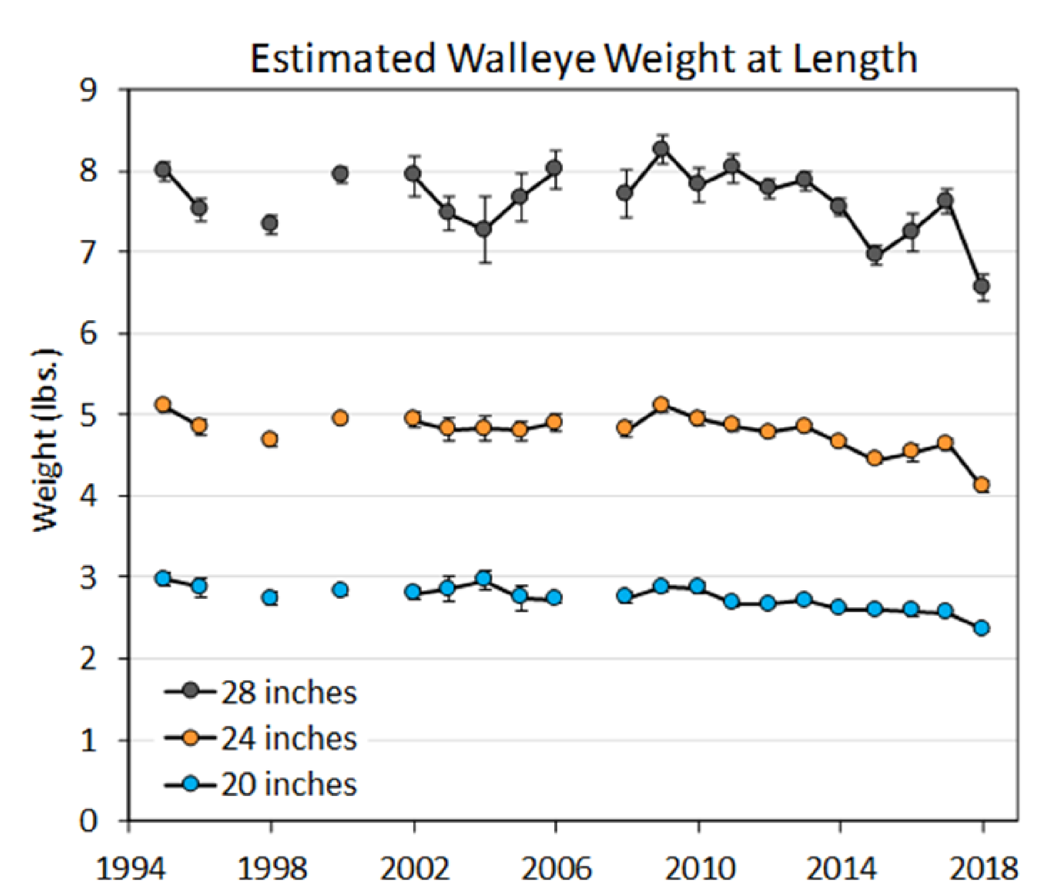


Figure 4.1.4. Estimated body weight (lbs.) of angler-caught walleye in the New York waters of Lake Erie at 20, 24, and 28 inches from 1995-2018. Error bars represent 95% confidence intervals.

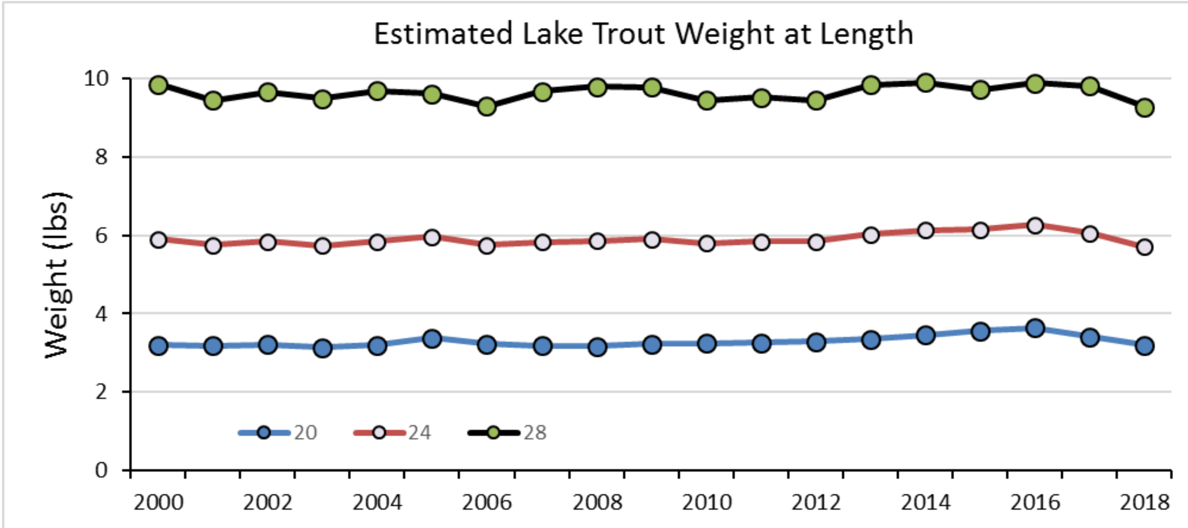


Figure 4.1.5. Estimated body weight (lbs.) of Lake Trout caught walleye in the New York coldwater assessment gill net survey in Lake Erie at 20, 24, and 28 inches from 2000-2018. Error bars represent 95% confidence intervals.

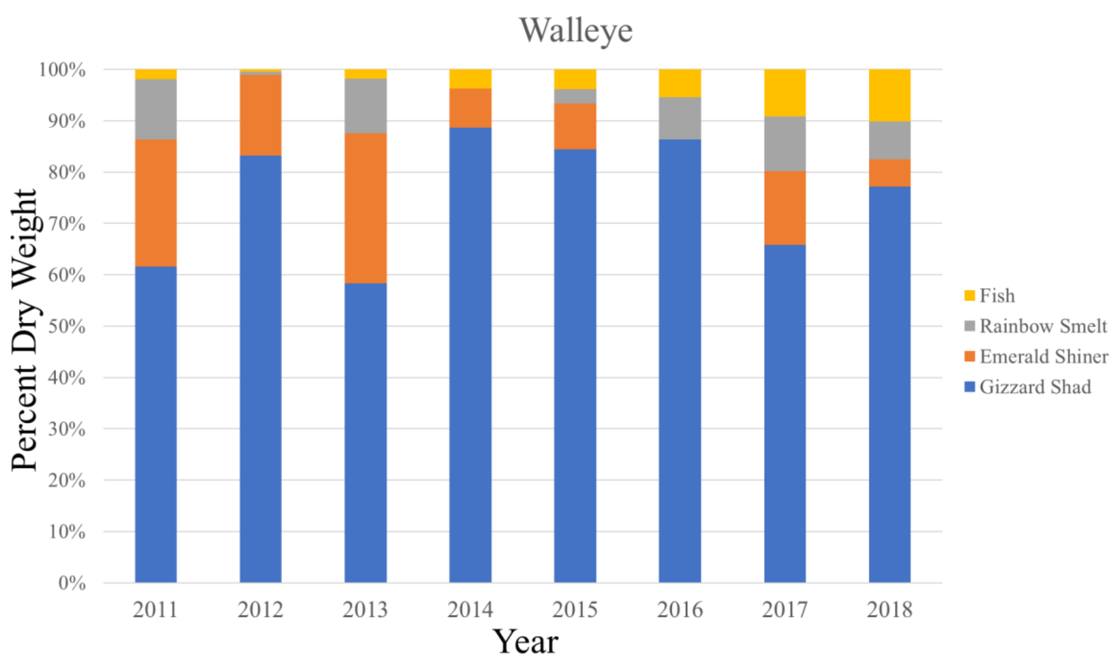


Figure 4.2.1. Adult Walleye diet composition (Percent dry weight) from non-empty stomachs collected in gill nets from central basin, Ohio waters of Lake Erie, 2011 - 2018.

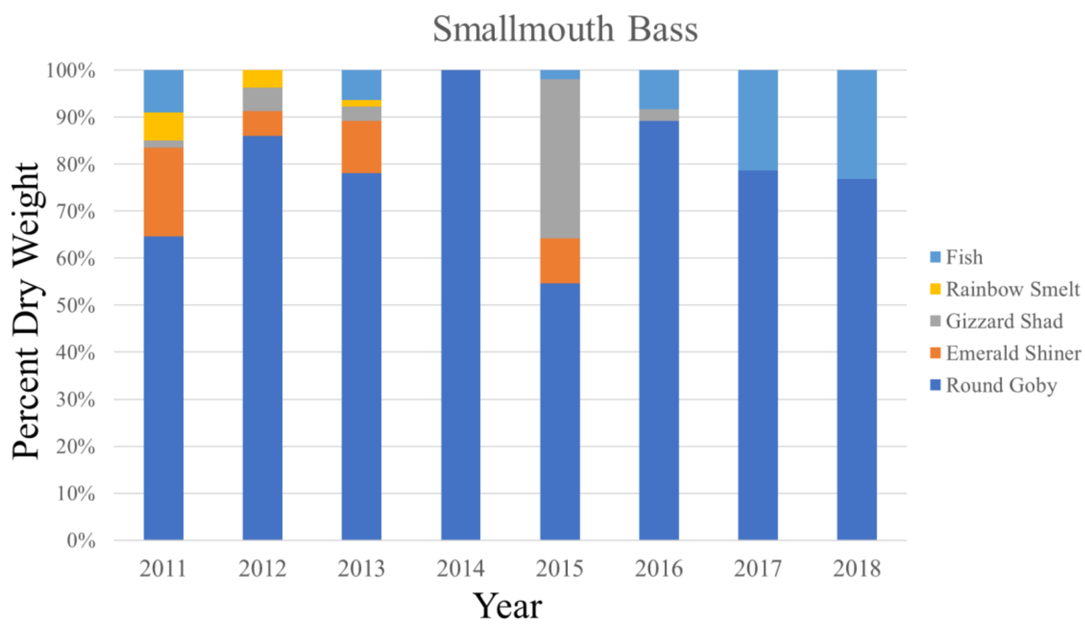


Figure 4.2.2. Adult Smallmouth Bass diet composition (Percent dry weight) from non-empty stomachs collected in gill nets from central basin, Ohio waters of Lake Erie, 2011 - 2018.

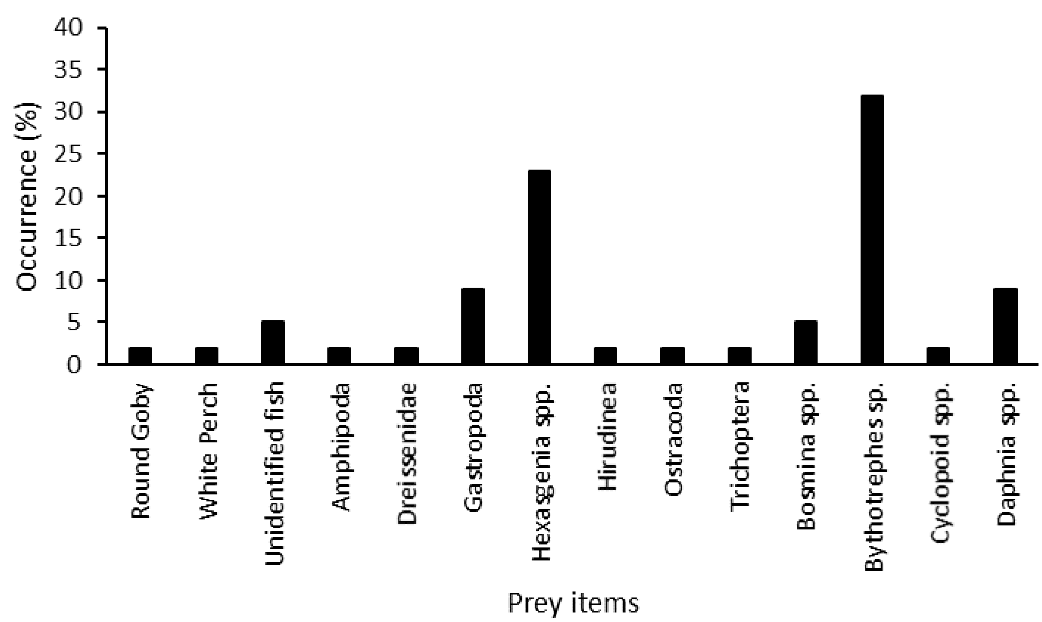


Figure 4.3.1. Frequency of occurrence of prey taxa in diets of Yellow Perch from western Lake Erie in September 2018.

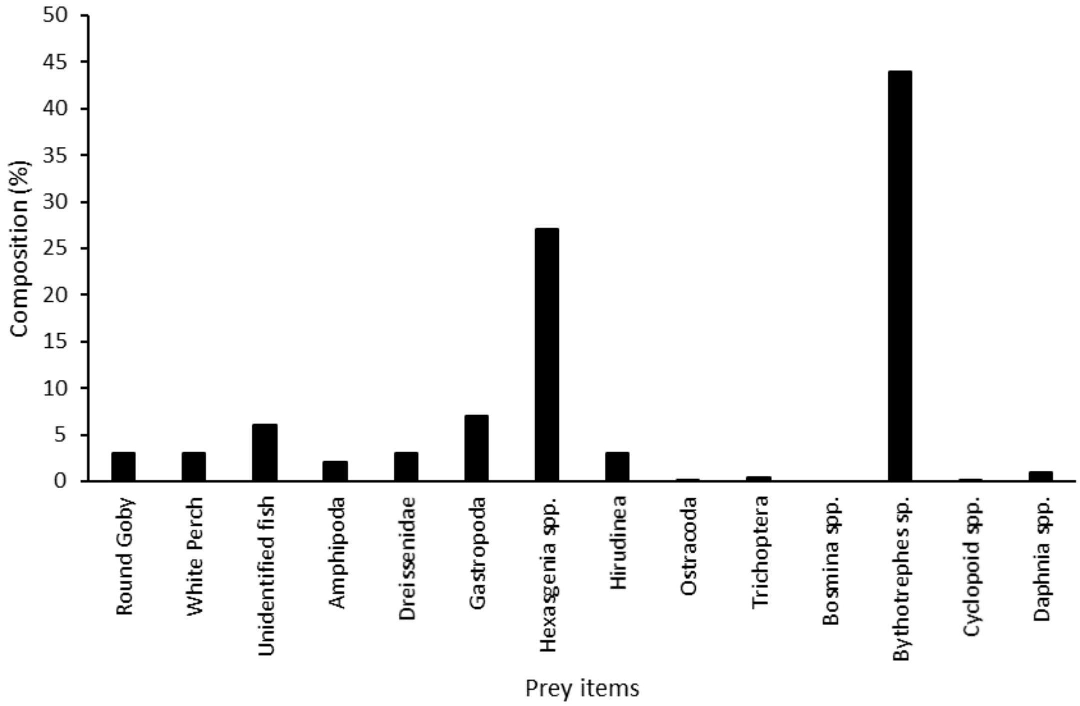


Figure 4.3.2. Percent composition of Yellow Perch diets (% dry weight) in western Lake Erie in September 2018.

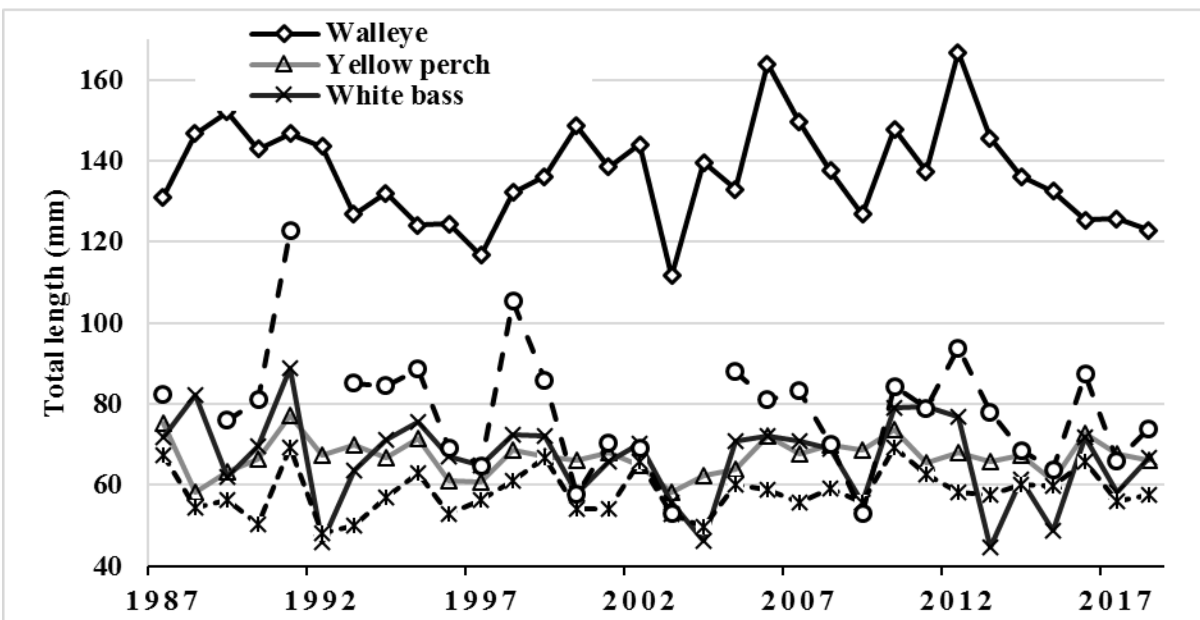


Figure 4.3.3. Mean total length (mm) of select age-0 fishes in western Lake Erie, August 1987- 2018.

## Charge 5: Develop and maintain a database to track Aquatic Invasive Species in Lake Erie

(P. Kočovský)

In 2016, the Lake Erie Committee added a charge to "Develop and maintain a database to track Aquatic Invasive Species (AIS) in Lake Erie." This charge was developed in recognition of the need for a systematic, centralized, lake-wide effort to track records of new, non-native species that might become invasive. The recognized need to better track status of the most recent invaders of management interest, such as Grass Carp, was the impetus for creating this new charge. Placing this charge with the Forage Task Group took advantage of the FTG's existing reporting structure, which includes sampling data from all agencies in all basins of Lake Erie, which has been a primary past source for detecting new invasive species, (e.g., Round Goby, White Perch).

We adopted the USFWS service list of injurious freshwater species (https://www.fws.gov/injuriouswildlife/11-freshwater-species.html) as the primary species to track and developing a relational database to track instances of new invasive species. All species on the USFWS list are believed to be 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). We also include Bighead Carp, Silver Carp, and Black Carp as species that are currently absent but potentially damaging to Lake Erie, Grass Carp, which have been reproducing in Lake Erie since at least 2011 (Chapman et al. 2013; Embke et al. 2016), and Rudd, which have reproducing populations in Ontario and New York waters connected to Lake Erie. We are also preparing a secondary list of "candidate species," and we will include other non-native species not on the injurious species or candidate lists as they are reported. This report includes only species reported to member agencies and may not be complete.

### Reported non-native species

Two Rudd were captured 8 August by electrofishing in Ashtabula Harbor, which is within the known geographic range of Rudd in the Great Lakes. There were no other new non-native species captured by or reported to Forage Task Group agencies.

Fifty-seven Grass Carp were captured in Lake Erie or its tributaries in 2018 (Figure 5.1.1). Twenty-five were diploid, 11 triploid and seven either were untested or of indeterminate ploidy. Two diploid, four triploid, and three fish of untested or indeterminate ploidy were captured in Michigan waters. Four fish were captured in commercial seines, two were delivered to MIDNR by bow fishermen, and one was captured by USFWS. One triploid Grass Carp was captured by a bow fisherman in Dunkirk Harbor, New York. Forty-three Grass Carp were captured in Ohio waters. Six were captured in commercial trap nets, three in May and June, and three in October. Twenty-seven were captured in the Sandusky River and three were captured in the Maumee River during a prescribed management action conducted 12-14 June. Seven fish were captured by either USFWS or ODNR crews targeting Grass Carp adults. Two triploid Grass Carp were captured in commercial trap nets in Ontario waters of western Lake Erie. One triploid and one untested Grass Carp were collected in Presque Isle Bay in Pennsylvania Waters. These were the first Grass Carp reported from Pennsylvania Waters of Lake Erie.

The number of diploid, triploid, and total Grass Carp captured in Lake Erie has increased since recording began in 2012 (Figure 5.1.2). The increase in 2014 reflects the first year state agencies began targeting capture of Grass Carp. The increase in captures reflect increased and targeted efforts to capture adults. For example, the effort led by Ohio DNR and supported by all other provincial, state, and federal agencies resulted in the capture of 30 fish in just three days, which was 72% of the total fish captured in 2017.

Additional targeted effort by Michigan State University and dedicated Grass Carp teams from MIDNR, ODNR, and USFWS provided all but 6 additional Grass Carp. No effort data were available to calculate catch per unit effort.

Tubenose Goby has been captured in Ontario and Michigan waters of western Lake Erie every year since 2015 (Figure 5.1.3). Tubenose Goby has been present in Lake Erie since the early 2000s. Some of the Tubenose Goby captured since 2015 have been in deeper waters and farther south and east since 2011 (Kočovský et al. 2011), representing an expansion of known habitats used by this non-native species.

There were no new non-native species reported to or captured by FTG agencies in 2018.

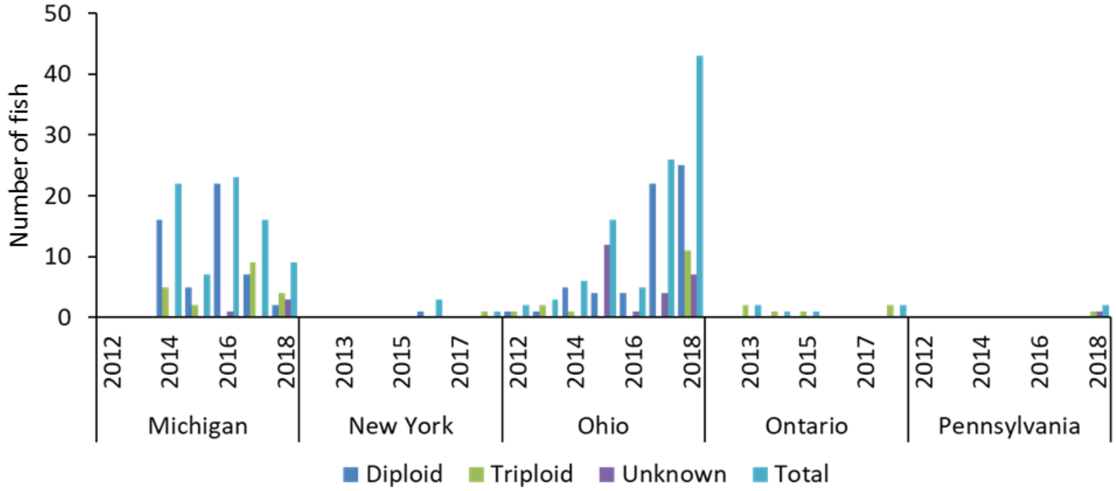


Figure 5.1.1 Numbers of Grass Carp captured in Lake Erie or its tributaries by jurisdiction, year, and reproductive status.

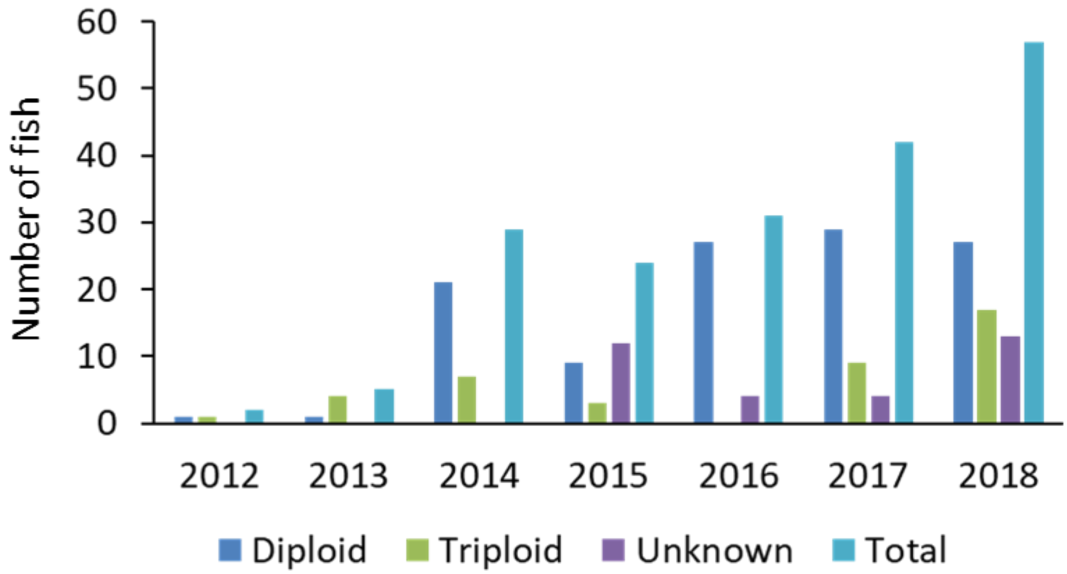


Figure 5.1.2 Total number of Grass Carp captured by year in Lake Erie by reproductive status.

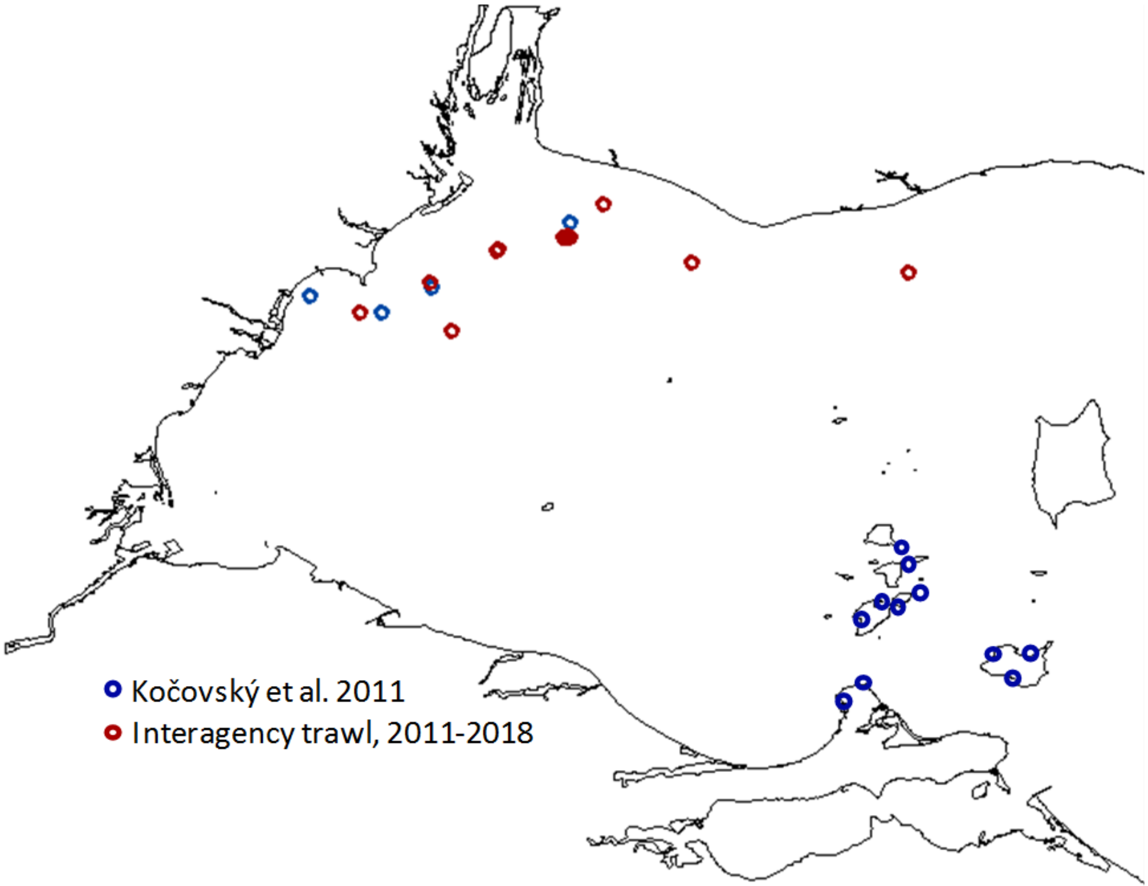


Figure 5.1.3  Tubenose Goby captures in western Lake Erie since 2008.

**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. 2019. Report of the Lake Erie Forage Task Group, March 2019. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission, Ann Arbor, Michigan, USA.

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