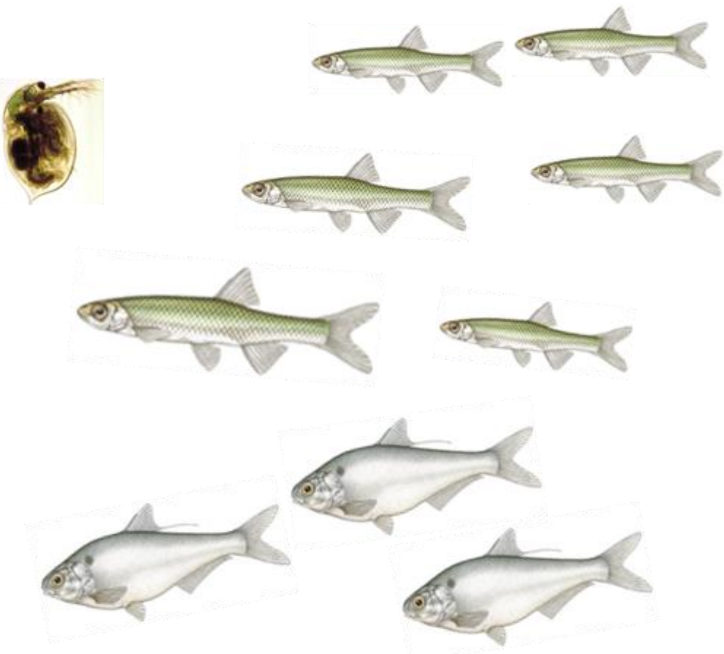
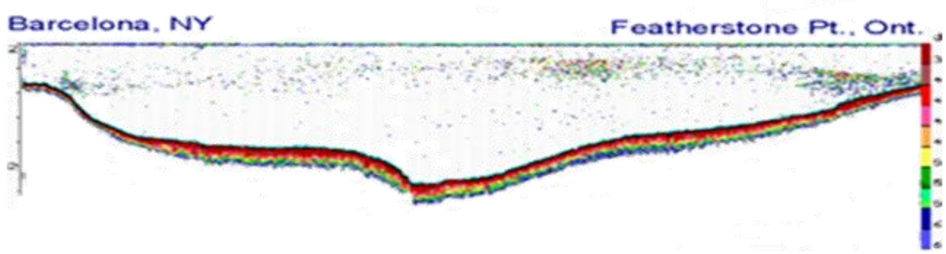
Report of the Lake Erie Forage Task Group

March 2016





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Zy Biesinger	- United States Fish and Wildlife Service, (USFWS) {Co-Chair}
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Presented to:

Standing Technical Committee
Lake Erie Committee
Great Lakes Fishery Commission

Charges to the Forage Task Group 2015-2016

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 Aquatic Invasive Species in Lake Erie

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, T. MacDougall, Z. Biesinger)

In 1999, the FTG initiated a Lower Trophic Level Assessment program (LTLA) within Lake Erie and Lake St. Clair. 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 17 years of Lake Erie data for summer surface temperature, summer bottom dissolved oxygen, chlorophyll *a* concentrations, zooplanktivory, water transparency and total phosphorus. Stations were only included in the analysis if there were at least 3 years each containing 6 or more sampling dates. Stations included in this analysis are stations 3, 4, 5 and 6 from the west basin, stations 7, 8, 9, 10, 11, 12, 13 and 14 from the central basin, and stations 15, 16, 17, 18, 19, 20 and 25 from the east basin (Figure 1.0.1). Station 25 (located off Sturgeon Point in 19.5 meters of water) was added in 2009.

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 ranges for total phosphorus are < 9 µg/L, summer water transparency of > 6 m, and chlorophyll *a* concentrations of < 2.5 µg/L.

Mean Summer Surface Water Temperature

Summer surface water temperature represents the temperature of the water at 0-1 meters 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=23.4 °C), becoming progressively cooler in the central (mean = 21.8 °C) and east basins (mean = 20.6 °C) (Figure 1.0.2). Annual means range from 21.6 °C (2009) to 25.2 °C (2006) in the west basin, 20.5 °C (2009) to 24.1°C (2012) in the central basin, and 18.5 °C (2003) to 22.4 °C (2005) in the east basin. Above series-average temperatures were evident across all basins in 2005, 2006, 2010, 2011 and 2012; below average temperatures occurred in 2000, 2003, 2004, 2008, and 2009. A slightly increasing trend in summer surface water temperature is evident for the central and east basins in this 17 year time series, but a slightly decreasing trend is evident for the west basin. In 2015, the mean summer surface water temperature was below the series-average in the west (22.6 °C) and east (19.8 °C) basins, but at above average in the central basin (22.5 °C).

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 2015, 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 2015, bottom DO was below the 2.0 mg/L threshold in the central basin on two occasions (Station 10 on 8/28/2015, 0.36 mg/L; Station 11 on 8/18/15, 1.89 mg/L) (Figure 1.0.3).

Dissolved Oxygen 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 at the Station 25 (Figure 1.0.3). No DO concentrations of less than 7.0 mg/L were recorded in the east basin in 2015.

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 17 year time series, fitting into eutrophic status rather than mesotrophic status (Figure 1.0.4). Annual variability is also the highest in the west basin. In 2015, the mean chlorophyll *a* concentration was 10.5 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 2015 (4.2 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 2015, the mean chlorophyll *a* concentrations were 1.5 µg/L in the nearshore waters of the east basin and 1.8 µg/L in the offshore waters. Chlorophyll *a* concentrations are most stable in the east basin.

Total Phosphorus

Total phosphorus levels in the west basin have exceeded FCO targets since the beginning of the LTLA monitoring program (Figure 1.0.5). In 2015, total phosphorus concentrations in the west basin increased to 69.2 µg/L and were in the hyper-eutrophic range. The value was heavily influenced by one exceptionally high value (1,655 µg/L) recorded on 10 August at Station 4 off the mouth of the Maumee River. Total phosphorus readings without this value are lower (35.5 µg/L) and near readings for the previous three years, but still remain well above targets. In the central basin, total phosphorus levels exceeded FCO targets from 2006 to 2014 but have declined in recent years (Figure 1.0.5). Total phosphorus measures in the central basin in 2015 were 17.1 µg/L, which was essentially equal to 2014 values and within the desired mesotrophic range for the second consecutive year. In the nearshore waters of the east basin, total phosphorus levels have remained stable and within the targeted mesotrophic range for nearly the entire time series (Figure 1.0.5). A gradual increasing trend was evident from 2006 through 2010, but a declining trend has been observed since 2010. Total phosphorus levels in the offshore waters of the east basin show a similar trend to nearshore waters, and have sometimes risen above the targeted oligotrophic range into the mesotrophic range in recent years. In 2015, mean total phosphorus concentrations in the east basin decreased slightly in the nearshore waters to 7.4 µg/L, which was below the targeted mesotrophic range for the second consecutive year. Phosphorus measures in the offshore waters of the east basin increased in 2015 to 8.4 µg/L but remained in the targeted oligotrophic range.

Water Transparency

Similar to other fish community ecosystem targets (i.e. chlorophyll *a*, total phosphorus), water transparency has been in the eutrophic range, which is below the FCO target in the west basin, for the entire time series (Figure 1.0.6). Mean summer Secchi depth in the west basin was 2.3 m in 2015, which was equal to 2014 measures. In contrast, water transparency in the central basin has remained within the targeted mesotrophic range for the entire series with the exception of 2015 (2.9 m), which was slightly below the mesotrophic target range (Figure 1.0.6). Transparency was in the oligotrophic range, which is above FCO targets for the nearshore waters of the east basin, from 1999 through 2006, but has been stable and within the FCO targets for the last nine years (Figure 1.0.6). In the offshore waters of the east basin, water transparency was within the oligotrophic target from 1999 through 2007, but shifted into the mesotrophic range in five of the last seven years. In 2015, mean summer Secchi depth was 5.7 m in the nearshore waters of the east basin, which was equal to measures in 2014 and within the targeted mesotrophic range, and 6.5 m in the offshore waters, which was within the targeted oligotrophic range. Mean summer Secchi depths have been steadily increasing in both areas since 2008.

Zooplankton Biomass

Zooplankton biomass varies among basins and years. In the west basin, the 2015 mean biomass was 241.3 mg/m^3, which was the highest value in the time series and well above the long term average of 87.4 mg/m^3 (Figure 1.0.7). Cladocerans provide the bulk of the biomass of zooplankton in the west basin. However, both calanoid and cyclopoid copepods were also abundant in 2015. In the central basin, mean zooplankton biomass declined for the third consecutive year to 78.1 mg/m^3. Copepods are higher in biomass in the central basin compared to the west basin, but cladocerans are less numerous. East basin zooplankton results are not yet available for 2014 and 2015, but overall zooplankton biomass is traditionally lower in the east basin compared to the central and west basins (Figure 1.0.7). Looking at larger trends, there appeared to be a gradient of high zooplankton biomass in the west and lower biomass in the east from 1999 to 2007. In addition, cladocerans were more dominant in the west basin than elsewhere. Since 2009, zooplankton biomass has been highest in the central basin, with the exception of 2011, when it was highest in the east basin and 2015, when it was highest in the west basin.

Distribution of New Zooplankters

For this review, data from stations 3, 4, 5, 6, 9, 10, 11, 12, 15, 16, 17, 18, 19 and 20 were included. *Bythotrephes longimanus* was first collected in Lake Erie in October 1985 (Bur *et al.* 1986). It is consistently present at central and east basin stations, but is very rare at west basin stations. Densities ranged from 0.001 to 6,370 individuals/m^3 and were generally higher from July through September.

Cercopagis pengoi was first collected in Lake Ontario in 1998, and by 2001 was also collected in the west basin of Lake Erie (Therriault et al. 2002). It first appeared in this sampling effort at station 5 in July 2001 and station 9 in September 2001. In subsequent years it has also been found at stations 5, 6, 9, 10, 15, 16, 17, 18 and 19. Except for the year 2002, when it was collected at 8 stations, *Cercopagis* is seen less frequently around the lake than *Bythotrephes*. Densities ranged from 0.03 to 876 individuals/m^3.

The first record of *Daphnia lumholtzi* in the Great Lakes was in the west basin of Lake Erie in August 1999 (Muzinic 2000). It was first identified in our seasonal sampling effort in August 2001 at stations 5 and 6, and at station 9 by September 2001. *Daphnia lumholtzi* was collected at stations 5 and 6 in 2002, and at stations 5, 6, 8 and 9 in 2004. Data are not available for these stations from 2005 through 2010, but in 2011 *D. lumholtzi* was found at station 5 and 6 with densities of 91 and 83 individuals/m^3, respectively. In 2007, it was found at station 18, the first and only year observed in the east basin; densities ranged from 0.002 to 91 individuals/m^3.

Fish Community Ecosystem Targets

Measures of lower trophic indicators (total phosphorus, transparency, chlorophyll *a*) in 2015 indicate that the west basin is in a eutrophic state. Current conditions favor a centrarchid (bass, sunfish) fish community instead of the targeted percid (Walleye, Yellow Perch) fish community (Table 1.0.2). In the central basin, the lower trophic measures in 2015 continue to fall within the targeted mesotrophic range preferred by percids. In the east basin, measures of total phosphorus, chlorophyll *a*, and transparency indicate a borderline mesotrophic/oligotrophic state for the nearshore waters but within the targeted oligotrophic range favored by salmonids in the offshore waters. In general, recent trophic measures across Lake Erie indicate that productivity is slowly declining.

Table 1.0.1. Ranges of selected lower trophic indicators for each trophic class and associated fish community (Leach et al. 1977; Ryder and Kerr 1978).

Trophic Class	Phosphorus (µg/L)	Chlorophyll a (µg/L)	Transparency (m)	Harmonic Fish Community
Oligotrophic	<9	<2.5	>6	Salmonids
Mesotrophic	9 - 18	2.5 - 5.0	3 - 6	Percids
Eutrophic	18 - 50	5.0 - 15	1 - 3	Centrarchids
Hyper-eutrophic	>50	>15	<1	Cyprinids

Table 1.0.2. Measures of key lower trophic indicators and current trophic class, by basin, from Lake Erie, 2015. The east basin is separated into nearshore and offshore.

Basin	Phosphorus (µg/L)	Chlorophyll a (µg/L)	Transparency (m)	Trophic Class
West	69.2	10.5	2.3	Eutrophic
Central	17.1	4.2	2.9	Mesotrophic
East - Nearshore	7.4	1.5	5.7	Oligotrophic
East - Offshore	8.4	1.8	6.5	Oligotrophic

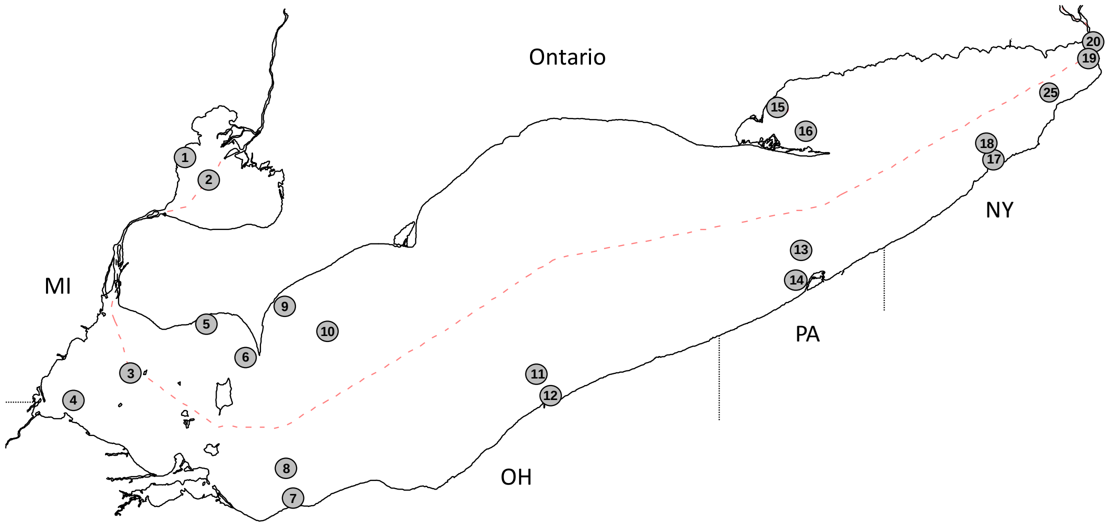

Figure 1.0.1. Lower trophic level sampling stations in Lake Erie and Lake St. Clair. Station 25 was added in 2009. Lake St. Clair stations were last sampled in 2005.

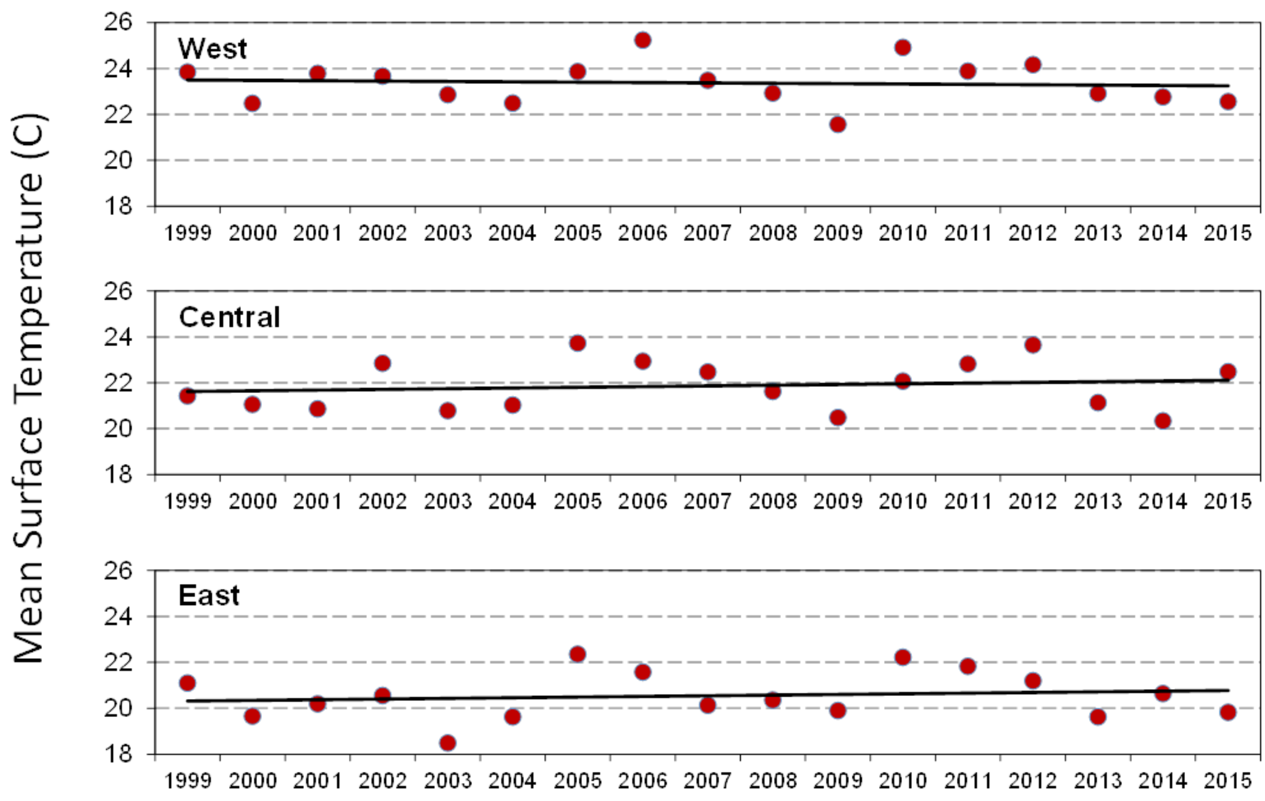

Figure 1.0.2. Mean summer (June-August) surface water temperature (°C) at offshore stations, by basin in Lake Erie, 1999-2015. Dark blue lines represent time-series average water temperature (1999-2012). Data included in this analysis by basin and station: West - 3, 6; Central – 8, 10, 11, 13; East – 16, 18, 19, 25.

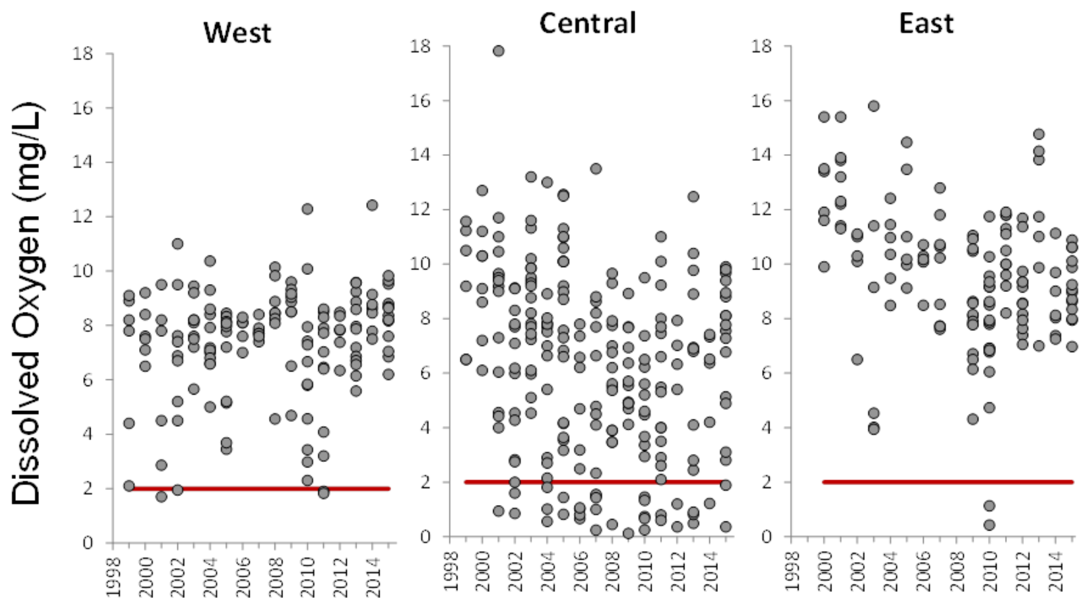

Figure 1.0.3. Summer (June-August) bottom dissolved oxygen (mg/L) concentrations for offshore sites by basin in Lake Erie, 1999-2015. The red horizontal line represents 2 mg/L, a level below which oxygen becomes limiting to the distribution of many temperate freshwater fishes. Data included in this analysis by basin and station: West - 3, 6; Central – 8, 10, 11, 13; East – 16, 18, 19, 25.

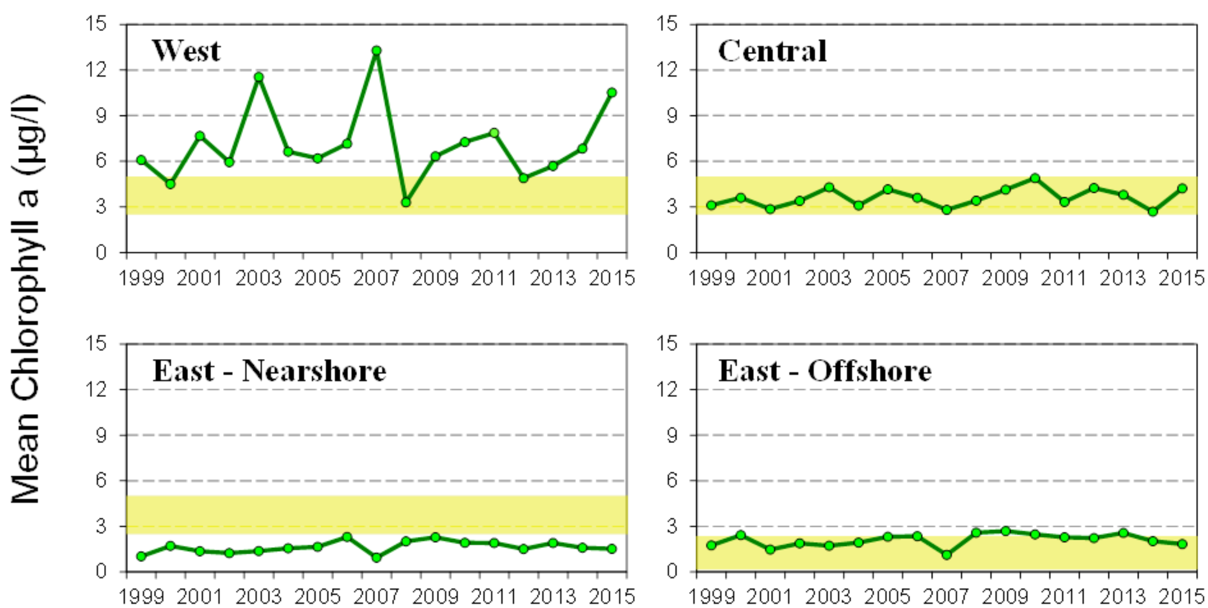

Figure 1.0.4. Mean chlorophyll *a* concentration (µg/L), weighted by month, by basin in Lake Erie, 1999-2015. The east basin is separated into nearshore and offshore. Yellow shaded areas represent targeted trophic class range. For this analysis data from stations 3 through 20, and 25 were included.

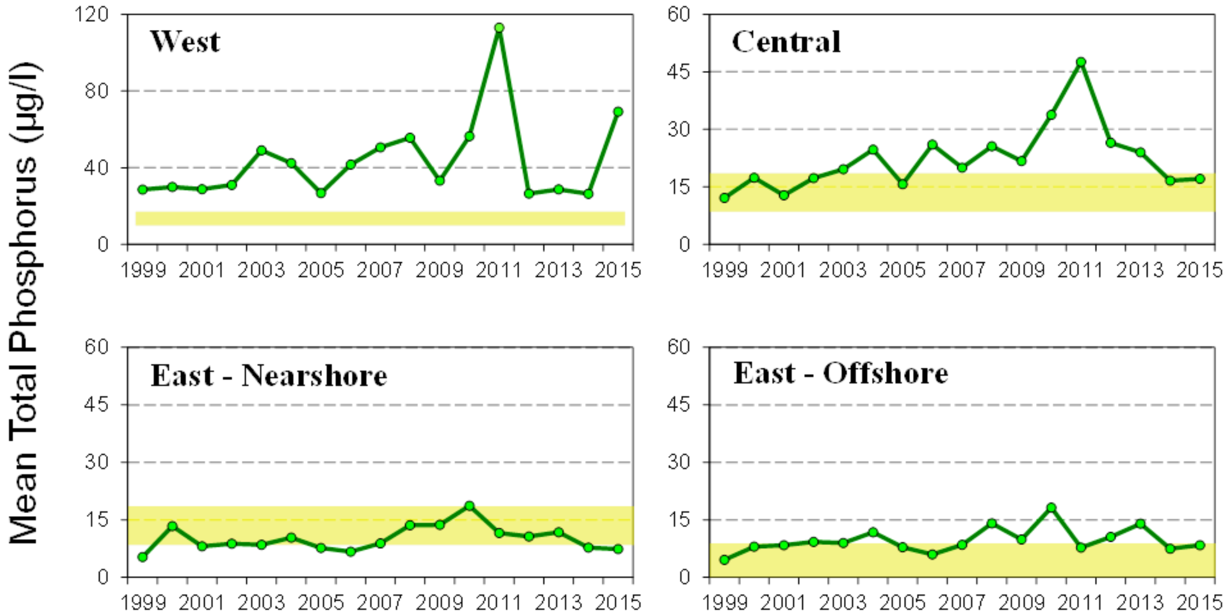

Figure 1.0.5. Mean total phosphorus (µg/L), weighted by month, for offshore sites by basin in Lake Erie, 1999-2015. The east basin is separated into nearshore and offshore. Yellow shaded areas represent the targeted trophic class range. For this analysis data from stations 3 through 20, and 25 were included.

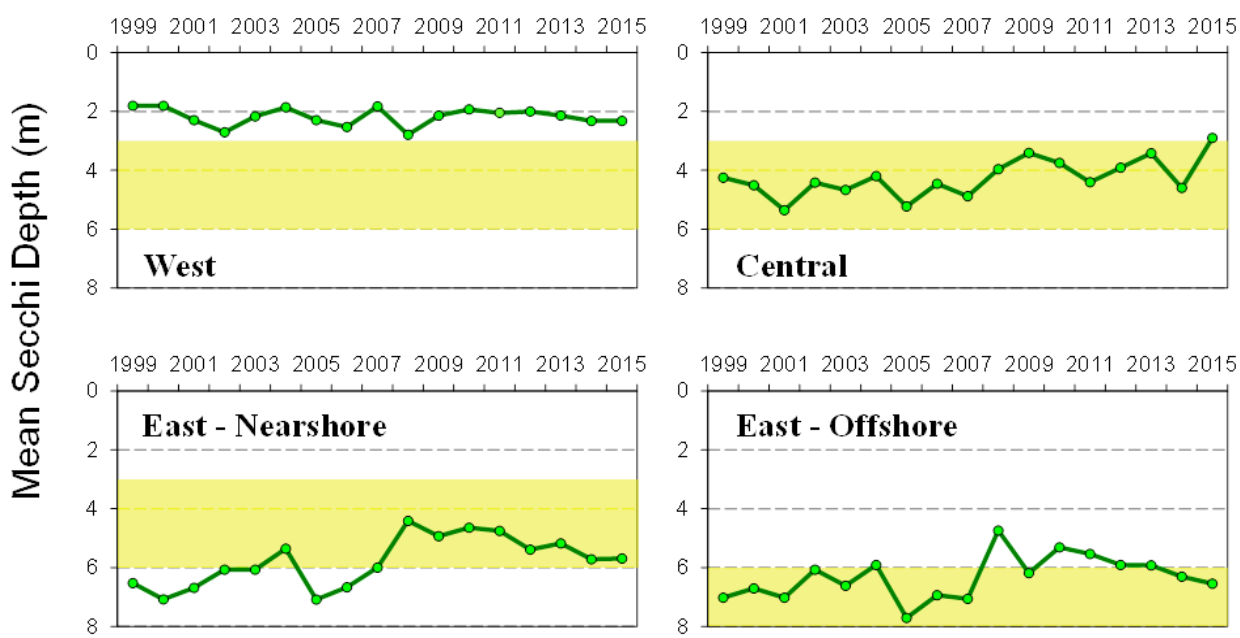

Figure 1.0.6. Mean summer (June-August) Secchi depth (m), weighted by month, by basin in Lake Erie, 1999-2015. The east basin is separated into inshore and offshore. Yellow shaded areas represent the targeted trophic class range. For this analysis data from stations 3 through 20, and 25 were included.

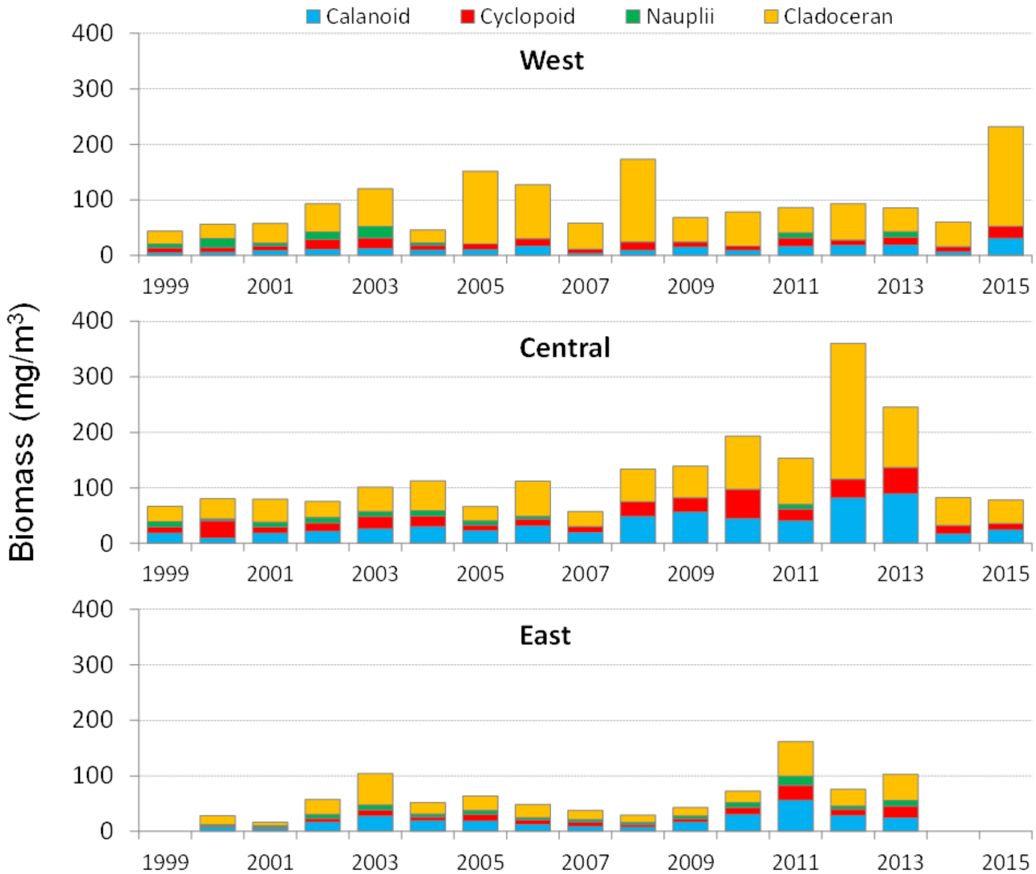

Figure 1.0.7. Mean zooplankton biomass (mg/m^3) by major taxonomic group by basin, 1999 through 2015. There is no data for 1999 and 2014-2015 in the eastern basin. West basin includes stations 3 through 6. Central basin includes stations 7 through14. East basin includes stations 15 through 20. Data excludes rotifers, and veligers. Harpacticoid zooplankton comprise a miniscule biomass for some 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 2014 Forage Status and Trends

Eastern Basin

- Total forage fish abundance in 2015 was above the 10-year average in Ontario's (ON) bottom trawl assessment and slightly below the 10-year average in New York's (NY) bottom trawl assessment
- Young-of-the-year (age-0) Rainbow Smelt density was above average in ON and NY and below average in PA
- Yearling-and-older (age-1+) Rainbow Smelt density was above average in ON and below average in NY and PA
- Young-of-the-year Yellow Perch density was below average in NY and ON
- Young-of-the-year Alewife density was low basin wide
- Young-of-the-year Gizzard Shad density increased basin wide
- Young-of-the-year Emerald Shiner density increased to above average in ON and was below average in NY and PA; age-1+ density was below average basin wide
- Spottail Shiner remained at low density throughout the east basin
- Round Goby densities increased in all agency surveys and were above 10-year averages for some surveys

Central Basin

- Forage fish abundance declined from 2014 and is below long term average (25 years, 1990-2014) in OH
- Young-of-the-year Yellow Perch abundance is below 10-year average in both PA and OH
- Young-of-the-year Rainbow Smelt abundance is at the 10-year average in PA, and mixed in OH (eastern OH below average, western OH above average)
- Yearling-and-older Rainbow Smelt densities are at the 10-year average in PA, above 10-year average in OH
- Young-of-the-year and Age-1+ Emerald Shiner densities were at the 10-year average in PA, but extremely low in OH
- Round Goby abundance is at (western OH) or below 10-year average (PA, eastern OH)
- Gizzard Shad indices were some of the highest in the time series in both PA and OH

West Basin

- Forage abundance and biomass below average levels
- Young-of-the-year Gizzard Shad density increased from 2014, above 10- year mean
- Young-of-the-year Rainbow Smelt density increased, but below 10-year mean
- Young-of-the-year and age-1+ Emerald Shiner indices declined from 2014; well below 10-year mean
- Young-of-the-year White Perch density declined from 2014 levels; half of 10-year mean
- Round Goby abundance is similar to 2014; well below 10-year mean
- Strong Age-0 Walleye recruitment in 2014; best since 2003; well above both 10-year and long-term means
- Young-of-the-year Yellow Perch recruitment declined from 2014, but remains well above 10-year and long-term means
- White Bass recruitment increased but is below 10-year mean
- Size of age-0 Walleye, Yellow Perch, White Bass and Smallmouth Bass were smaller than average; age-0 White Perch were near long term means;
- Fall Walleye diets showed reliance on Gizzard Shad

2.2 Eastern Basin (J. Trumpickas, J. Markham and M. Hosack)

Forage fish abundance and distribution in eastern Lake Erie is determined chiefly from annual bottom trawl assessments conducted independently by the basin agencies (also see East Basin Hydroacoustic Survey section of this report). During 2015, NYSDEC, OMNRF and PFBC continued long-term trawling programs in their respective jurisdictions. A total of 34 trawl tows were sampled across New York waters in 2015 (bringing the total years of trawl data to 24), 110 trawl tows were completed in nearshore (35 years of data) and offshore (32 years of data) areas of Long Point Bay during Ontario's various trawl assessments and 8 trawls were completed in Pennsylvania waters of the East Basin (26 years of data) (Figure 2.2.1).

Rainbow Smelt are the principal prey fish species of piscivores in the offshore waters of eastern Lake Erie and the most abundant forage species in most years and jurisdictions. In 2015, Rainbow Smelt were the most abundant forage species in Ontario and New York waters of the East Basin (Figure 2.2.2). Young-of-the-year density in the Ontario trawl program was the highest since 2003 (3245/ha) and age-1+ density was the highest since 2009 (411/ha) (Table 2.2.1). In the New York survey, age-0 density (2856/ha) was down from a record high in 2014 but remained well above average. Yearling-and-older density in New York increased to 575/ha from low numbers in 2014. In Pennsylvania waters, both age-0 (108/ha) and age-1+ (35/ha) densities were much lower than in the other jurisdictions. The mean fork length of age-0 Rainbow Smelt (58 mm), as measured in the Ontario survey, increased in 2015 but remained below average, while yearlings (98 mm) decreased to below average values (Figure 2.2.3).

The densities of non-smelt forage fish species in eastern Lake Erie varied by jurisdiction (Table 2.2.1, Figure 2.2.2). Recruitment of age-0 Emerald Shiner was high in Ontario waters (347/ha) in 2015, increasing to above average levels. In contrast, age-0 Emerald Shiner density was below average in New York (134/ha) and Pennsylvania (54/ha). Yearling-and-older Emerald Shiner density was below average in all jurisdictions. Young-of-the-year White Perch densities in Pennsylvania were much higher (277/ha) than in New York (17/ha) and Ontario (<1/ha) waters. Young-of-the-year Gizzard Shad densities increased in all jurisdictions, with the highest density in Pennsylvania (34/ha). Trout-Perch (all ages) remained a significant portion of the catch only in New York, with densities of 32/ha, although this is well below average. Densities of all ages of Spottail Shiner continued to be low in all jurisdictions (<6/ha). Similarly, age-0 Alewife numbers remained low in all jurisdictions (<6/ha).

Round Goby became an important new species in the eastern basin forage fish community when it appeared in the late 1990s. By 2001, Round Goby was the most or second most numerically abundant species caught in agency index trawl gear across eastern Lake Erie, with densities peaking around 2007. In 2015, an increase in Round Goby density (all ages) was observed in all East Basin trawl programs compared to the previous year. In 2015, density was highest in New York (430/ha) and lowest in Pennsylvania (39/ha) (Table 2.2.1). Round Goby density in New York, while below average, was at its highest level since 2009. Two of the three Ontario trawl surveys had 2015 densities higher than average.

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. There are no annual trawl surveys in Ontario waters of the central basin. 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, PA. In 2015, a total of 47 trawl tows were completed in the central basin, 11 in Ohio East, 12 in Ohio West, and 24 in Pennsylvania.

In 2015, overall forage abundance in Ohio waters declined from 2014 and was below the long term average for the 26 year survey (Figure 2.3.2). The largest declines were in the Rainbow Smelt and soft-rayed groups (primarily Emerald Shiners). The clupeid and spiny-rayed groups did increase from 2014, but the increase was not enough to offset the sharp declines in Rainbow Smelt and soft-rayed groups. All forage group density estimates were below the 25-year average except clupeids. In Pennsylvania, Rainbow Smelt were the primary forage species prior to 1998, when Round Goby entered the system and became the primary soft-rayed forage species (Figure 2.3.3). Recently, spiny-rayed species, age-0 White Perch and age-0 Yellow Perch have been the most abundant forage group in Pennsylvania.

Trends in Rainbow Smelt abundance were not consistent across central basin surveys. Young-of-the-year Rainbow Smelt indices decreased in Ohio waters from 2014, and were above average in the west, but below average in the east (Table 2.3.1). The Pennsylvania index was above average and is the second highest in the time series. Yearling-and-older Rainbow Smelt indices increased in Ohio and were above average. In Pennsylvania, the age-1+ index was the second highest in the time series, but was slightly below average (Table 2.3.2).

In 2015, Pennsylvania indices for age-0 and age-1+ Emerald Shiner were near or slightly below average. In contrast, Emerald Shiners were almost absent from Ohio surveys. Young-of-the-year indices were the lowest (Ohio West) and second lowest (Ohio East) in the time series (Table 2.3.1). Yearling –and-older indices were the lowest in the time series, less than 2 fish/ha (Table 2.3.2).

Round Goby first appeared in central basin trawl surveys in Ohio in 1994 and in Pennsylvania by 1997. Generally, densities of this exotic species have tended to be higher in eastern relative to western areas of the basin. This pattern was observed again in 2015 for age-0, but not for age-1+, and trends in density estimates were not consistent across the basin. Young-of-the-year and age-1+, Ohio West indices increased from 2014 and were above average, while Ohio East indices decreased from 2014 and were below average. The Pennsylvania age-0 index was above average, while the age-1+ index was below average.

Young-of-the-year Gizzard Shad patterns were more typical of historic patterns in 2015 with higher densities occurring in western areas of the basin compared to the East (Table 2.3.1). Gizzard Shad indices from 2015 were the highest in the time series in Pennsylvania and Ohio East, and second highest in Ohio West. Young-of-the-year Alewives are not routinely captured in Ohio and Pennsylvania trawl surveys and were not encountered in any of the trawl surveys in 2015.

Since 2005, Yellow Perch cohorts in the central basin have tended to be strongest in the east relative to the west. In 2015, Yellow Perch age-0 indices were below average in all areas of the central basin (Table 2.3.1). Yearling-and-older indices in both Ohio surveys increased from 2014, with above average densities in Ohio West and below average densities in Ohio East. The Pennsylvania index for age-1+ was also below average (Table 2.3.2).

White Perch indices in Pennsylvania were the highest in the time series for age-0 and age-1+. Young-of-the-year indices in Ohio increased from 2014, but were below average. Yearling-and-older indices in Ohio were the lowest in the time series and have been declining since 2013.

2.4 West Basin (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 only 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 (FTG) 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 OMNR 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 OMNR 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 initiated, and fishing power correction (Table 2.4.1) factors 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/ha or number/m3) 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-finned fish (Rainbow Smelt, Emerald and Spottail Shiners, other cyprinids, Silver Chub, Trout-Perch, and Round Gobies), and spiny-rayed fish (age-0 for each of 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).

2015 Results

In 2015, hypolimnetic dissolved oxygen levels were not below the 2 mg per liter threshold at any site during the August trawling survey. In total, data from 70 sites were used in 2015 (Figure 2.4.1).

Total forage abundance was below average in 2015, the second year of decline (Figure 2.4.2). Spiny-rayed species decreased 24% compared to 2014, while clupeids and soft-rayed species increased 23% and 3%, respectively. Total forage abundance averaged 3,694 fish/ha across the western basin, decreasing 14% from 2014, and residing below the long-term average (5,229 fish/ha). Clupeid density was 1,052 fish/ha (average 1,148 fish/ha), soft-rayed fish density was 216 fish/ha (average 540 fish/ha), and spiny-rayed fish density was 2,425 fish/ha (average 3,540 fish/ha). Relative abundance of the dominant species includes: age-0 White Perch (45%), age-0 Gizzard Shad (28%), and age-0 Yellow Perch (13%). Total forage biomass in 2015 was similar to 2014, increasing only 4% (Figure 2.4.3). Relative biomass of clupeid, soft-rayed, and spiny-rayed species was 47%, 1%, and 52%, respectively, and differed from their respective historic averages of 30%, 7%, and 63%. Spatial maps of forage distribution were constructed using FPC-corrected site-specific catches (number/ha) of the functional forage groups (Figure 2.4.4). Abundance contours were generated using kriging techniques to interpolate abundance among trawl locations. Clupeid catches were highest near Sandusky Bay and Point Pelee. Soft-rayed fish were most abundant near Pelee Island. Spiny-rayed abundance was distributed relatively evenly throughout the basin.

Recruitment of individual species is highly variable in the western basin. Young-of-the-year Yellow Perch (494/ha) decreased relative to 2014, while age-0 Walleye abundance (84/ha) increased sharply (Figure 2.4.5); both were well above long-term means. Young-of-the-year White Perch (1,673/ha) dipped below the 2014 abundance. Young-of-the-year White Bass (62.3/ha) increased but remains well below the long-term mean. Young-of-the-year Rainbow Smelt increased relative to the long-term mean in 2015 (108/ha). Young-of-the-year Gizzard Shad (1,052/ha) increased relative to 2014, above the long-term mean, while age-0 Alewife were almost non-existent (Figure 2.4.6). Densities of age-0 (10.5/ha) and age-1+ Emerald Shiners (1.4/ha) remain well below the long-term mean (Figure 2.4.7). Density of Round Goby (43.9/ha) remained nearly identical to 2014, one of the lowest abundances since their appearance in 1997.

Table 2.2.1 Indices of 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. Indicies are reported as arithmetic mean number caught per hectare (NPH) for the age groups young-of-the-year (YOY), yearling-and-older (YAO), and all ages (ALL). Long-term averages are reported as the mean of the annual trawl indices for the most recent 10-year period (2005-2014) and for the two most recent completed decades. Agency trawl surveys are described below. Pennsylvania FBC (PA-Fa) did not conduct a fall index trawl survey in 2006, 2010, 2011, 2013, and 2014 and the 2008 survey was a reduced effort of four tows sampled in a single day.

	Age	Trawl	Year										10-Yr & Long-term Avg. by decade		
Species	Group	Survey	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	10-Yr	2000's	1990's
Rainbow	YOY	ON-DW	3245.2	1001.6	217.9	1657.7	509.2	326.9	148.2	1293.0	991.3	1256.0	739.3	1391.5	431.7
Smelt	YOY	NY-Fa	2856.1	5379.7	736.0	413.6	1580.4	1416.6	71.5	2128.9	2888.1	508.8	1638.3	1524.9	1450.9
	YOY	PA-Fa	107.7	NA	NA	584.5	NA	NA	51.1	14.8	262.0	NA	192.9	112.6	403.7
	YAO	ON-DW	411.0	4.6	165.3	367.8	277.1	222.7	1654.3	77.3	232.8	136.2	315.6	360.7	358.6
	YAO	NY-Fa	575.1	24.2	44.6	22.2	640.0	997.8	3010.0	546.5	178.3	162.9	602.2	753.4	581.6
	YAO	PA-Fa	34.6	NA	NA	21.5	NA	NA	412.9	1.8	986.6	NA	284.5	179.0	1267.1
Emerald	YOY	ON-DW	346.7	2.9	58.7	438.3	70.3	117.6	54.8	16.0	29.3	452.3	188.6	463.2	52.3
Shiner	YOY	NY-Fa	134.1	512.9	127.6	94.3	2930.1	62.9	48.5	3.7	150.9	778.5	500.1	194.0	112.4
	YOY	PA-Fa	53.7	NA	NA	14.1	NA	NA	1040.1	0.0	82.5	NA	227.4	199.5	42.1
	YAO	ON-DW	6.5	2.5	188.6	119.2	201.1	30.7	40.1	95.2	149.8	4200.3	516.6	819.0	37.7
	YAO	NY-Fa	24.2	801.8	65.4	93.8	1826.2	20.6	156.4	18.2	84.8	925.5	414.4	290.8	105.4
	YAO	PA-Fa	115.2	NA	NA	83.6	NA	NA	1327.1	0.0	4723.0	NA	1237.2	692.2	9.9
Spottail	YOY	ON-OB	5.8	5.0	8.1	19.1	2.5	3.0	3.7	37.8	35.2	19.8	19.3	119.3	815.9
Shiner	YOY	ON-IB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.1	0.2	0.5	113.9
	YOY	NY-Fa	0.0	0.1	0.0	1.8	0.7	6.5	0.1	0.3	0.1	0.5	1.0	5.6	19.9
	YOY	PA-Fa	0.0	NA	NA	0.0	NA	NA	1.3	0.0	0.0	NA	0.3	0.1	3.1
	YAO	ON-OB	1.5	0.2	3.0	1.6	0.5	2.1	3.3	7.5	4.1	10.4	3.6	10.8	74.6
	YAO	ON-IB	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.0
	YAO	NY-Fa	0.0	0.2	0.3	2.0	29.0	10.4	5.1	1.5	0.0	4.2	5.7	6.4	4.0
	YAO	PA-Fa	0.0	NA	NA	0.1	NA	NA	0.0	0.0	0.0	NA	0.0	0.0	5.2
Alewife	YOY	ON-DW	0.7	0.0	17.7	707.3	2.1	0.9	0.1	2.3	1.0	78.6	81.0	22.5	231.2
	YOY	ON-OB	3.4	0.0	26.1	6.0	6.8	0.0	1.9	11.9	44.6	711.8	82.0	82.1	88.5
	YOY	NY-Fa	5.4	0.0	218.2	183.8	12.4	15.4	0.0	5.6	22.2	30.3	51.6	94.2	52.0
	YOY	PA-Fa	0.0	NA	NA	4.3	NA	NA	0.0	0.0	8.1	NA	2.5	1.1	2.1
Gizzard	YOY	ON-DW	0.4	0.0	0.0	47.6	18.9	13.3	0.4	86.5	34.6	1.4	20.4	21.3	7.5
Shad	YOY	ON-OB	10.1	0.4	0.3	20.0	3.4	3.8	0.0	4.0	22.0	28.7	8.4	7.6	13.4
	YOY	NY-Fa	3.2	0.6	3.8	4.7	15.0	40.9	5.3	10.8	11.7	14.2	11.1	11.9	4.3
	YOY	PA-Fa	34.1	NA	NA	1.0	NA	NA	0.0	0.0	0.0	NA	0.2	0.0	0.3
White	YOY	ON-DW	0.5	0.0	0.0	0.8	0.0	1.6	0.6	5.4	0.1	0.9	1.0	2.9	1.8
Perch	YOY	ON-OB	0.2	0.0	0.0	0.9	0.0	0.0	0.0	2.1	0.7	1.2	0.5	2.8	17.6
	YOY	NY-Fa	16.9	35.2	4.4	18.3	36.5	157.3	20.2	431.5	34.6	91.9	93.0	74.3	29.3
	YOY	PA-Fa	276.9	NA	NA	370.6	NA	NA	645.0	0.6	422.2	NA	296.7	232.8	68.1
Trout	All	ON-DW	0.1	0.0	0.0	0.0	0.0	0.3	0.8	0.8	0.8	1.1	0.4	0.9	0.6
Perch	All	NY-Fa	32.3	63.3	148.8	338.9	654.3	461.6	516.6	996.4	562.2	520.3	559.2	825.1	406.9
	All	PA-Fa	1.5	NA	NA	48.7	NA	NA	619.0	0.6	153.7	NA	200.0	142.0	57.5
Round	All	ON-DW	67.2	0.5	14.5	129.0	125.4	9.7	43.6	452.6	973.2	93.3	190.9	235.9	0.0
Goby	All	ON-OB	359.1	98.5	76.3	68.0	103.3	67.6	91.2	63.4	73.9	32.7	70.3	86.9	0.1
	All	ON-IB	151.6	95.4	49.6	80.2	114.6	135.1	280.5	211.8	263.0	34.0	128.5	120.0	0.1
	All	NY-Fa	430.3	136.8	83.9	180.2	165.8	173.3	502.6	466.8	1293.2	846.7	455.2	654.4	1.0
	All	PA-Fa	39.1	NA	NA	31.0	NA	NA	371.6	441.0	1771.1	NA	682.9	1161.3	33.0

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

Ontario Ministry of Natural Resources 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. Indices are reported as NPH; 90's Avg. is for the period 1990 to 1999; 00's Avg. is for the period 2000 to 2009.

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. Indices are reported as NPH; 90's Avg. is for the period 1990 to 1999; 00's Avg. is for the period 2000 to 2009.

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. Indices are reported as NPH; 90's Avg. is for the period 1990 to 1999; 00's Avg. is for the period 2000 to 2009.

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. Indices are reported as NPH; 90's Avg. is for the period 1992 to 1999; 00's Avg. is for the period 2000 to 2009.

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. Indices are reported as NPH; 90's Avg. is for the period 1990 to 1999; 00's Avg. is for the period 2000 to 2009.

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 2005-2015. 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	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Mean
Yellow	OH West	43.9	8.3	151.0	31.5	1.6	41.1	10.3	69.2	8.9	37.7	19.6	40.4
Perch	OH East	156.2	17.0	177.8	52.8	0.5	96.3	15.1	134.4	8.9	49.1	18.6	70.8
	PA	4.3	-	10.0	863.4	14.2	-	-	481.6	28.0	-	107.0	233.6
White	OH West	1,047.2	388.8	1,096.2	468.1	379.0	254.8	346.6	1,709.6	174.7	135.0	371.0	600.0
Perch	OH East	2,034.5	41.5	1,095.9	91.6	34.6	190.3	72.1	661.9	200.1	99.4	338.8	452.2
	PA	26.1	-	17.4	199.0	146.3	-	-	380.1	2.2	-	758.6	128.5
Rainbow	OH West	8.7	69.6	78.4	735.7	267.8	776.2	29.8	84.4	126.0	747.8	447.0	292.4
smelt	OH East	44.4	513.6	702.4	3,997.7	0.3	421.6	247.3	319.1	12.8	1,709.5	236.4	796.9
	PA	9.3	-	34.8	552.2	23.1	-	-	10.4	132.8	-	148.1	127.1
Round	OH West	40.8	13.7	26.8	19.0	24.5	28.4	100.8	18.2	17.5	6.3	56.8	29.6
Goby	OH East	148.1	41.7	273.1	26.3	1.0	41.8	256.0	53.9	45.8	86.2	66.8	97.4
	PA	110.8	-	224.0	227.1	72.0	-	-	3.3	11.7	-	124.1	108.2
Emerald	OH West	630.4	656.5	36.3	25.0	7.5	8.8	361.7	951.3	2218.5	1369.3	3.5	626.5
Shiner	OH East	279.8	1003.6	63.7	20.2	1.7	234.9	103.7	2188.5	306.2	650.1	13.2	485.2
	PA	10.0	-	0.8	0.0	304.6	-	-	0.0	31.6	-	57.7	57.8
Spottail	OH West	0.1	0.0	2.1	3.4	0.4	0.0	0.6	0.0	0.0	2.5	0.0	0.9
Shiner	OH East	1.1	0.2	0.5	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.4	0.2
	PA	0.0	-	0.0	0.0	0.0	-	-	0.0	0.0	-	0.0	0.0
Alewife	OH West	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0	52.1	0.0	0.0	5.5
	OH East	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.1	36.1	0.0	0.0	3.9
	PA	0.0	-	0.0	0.0	0.0	-	-	2.8	5.0	-	0.0	1.3
Gizzard	OH West	13.4	36.8	183.8	33.2	52.6	2.6	675.8	98.7	304.2	33.8	568.0	143.5
Shad	OH East	15.7	27.7	15.5	63.1	3.9	8.5	4.2	28.7	39.5	7.3	455.6	21.4
	PA	0.7	-	0.0	0.0	0.0	-	-	0.0	0.0	-	8.7	0.1
Trout-	OH West	0.1	0.2	0.8	0.3	0.3	0.7	1.6	0.0	0.1	0.3	0.4	0.4
perch	OH East	1.6	0.1	5.4	0.1	0.2	1.4	2.7	0.2	0.0	0.6	1.2	1.2
	PA	0.7	-	10.8	126.1	28.2	-	-	0.0	0.0	-	2.2	27.6

\- The Pennsylvania Fish and Boat Commission was unable to sample in 2006, 2010, 2011 and 2014.

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 2005-2015. 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											
Species	Survey	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Mean
Yellow	OH West	19.2	4.6	20.7	53.4	20.2	11.9	6.3	7.4	34.9	15.4	41.3	19.4
Perch	OH East	132.3	11.9	37.0	26.4	139.4	12.4	55.5	23.3	109.5	24.2	30.2	57.2
	PA	49.0	-	27.4	76.4	121.8	-	-	117.7	73.7	-	59.0	77.7
White	OH West	34.0	66.9	24.0	78.0	45.8	32.6	25.8	45.8	195.9	5.8	1.7	55.5
Perch	OH East	20.1	34.7	16.8	36.6	282.3	44.8	49.8	7.7	546.9	4.4	1.4	104.4
	PA	0.0	-	0.8	4.2	62.6	-	-	7.8	18.4	-	78.9	15.7
Rainbow	OH West	108.5	20.7	43.2	10.5	528.3	18.0	28.3	12.9	17.1	34.9	340.8	82.2
Smelt	OH East	30.8	17.3	532.4	64.9	109.1	56.9	216.4	143.1	485.6	15.0	295.4	167.2
	PA	1.4	-	10.8	3.5	406.5	-	-	20.5	25.1	-	69.7	78.0
Round	OH West	38.3	15.4	26.9	63.8	60.4	44.0	68.6	11.8	24.3	6.9	35.8	36.0
Goby	OH East	263.0	71.0	185.6	167.8	19.3	36.0	118.1	27.0	46.3	89.1	72.4	102.3
	PA	915.7	-	356.8	326.6	76.0	-	-	72.9	8.6	-	50.3	292.8
Emerald	OH West	266.7	500.6	300.0	561.2	127.7	51.5	138.2	998.8	298.0	55.8	0.9	329.9
Shiner	OH East	479.6	406.0	27.8	1,159.4	167.8	375.1	149.7	433.2	8.4	333.5	1.8	354.1
	PA	75.1	-	793.2	28.0	172.5	-	-	8.9	17.2	-	179.5	182.5
Spottail	OH West	0.2	0.8	1.6	2.4	1.9	0.0	20.7	0.0	0.5	1.7	0.0	3.0
Shiner	OH East	3.8	0.6	0.6	2.9	0.0	0.0	3.1	3.0	2.9	0.0	0.0	1.7
	PA	0.0	-	0.0	0.0	0.0	-	-	0.0	0.0	-	0.0	0.0
Trout-	OH West	17.1	7.5	4.2	3.3	0.9	0.7	3.3	1.6	3.3	0.6	0.7	4.3
perch	OH East	76.2	4.3	6.7	8.4	1.5	5.0	7.9	11.7	1.0	0.4	3.0	12.3
	PA	63.6	-	15.8	61.7	127.5	-	-	30.4	9.3	-	8.3	51.4

\- The Pennsylvania Fish and Boat Commission was unable to sample in 2006, 2010, 2011 and 2014.

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

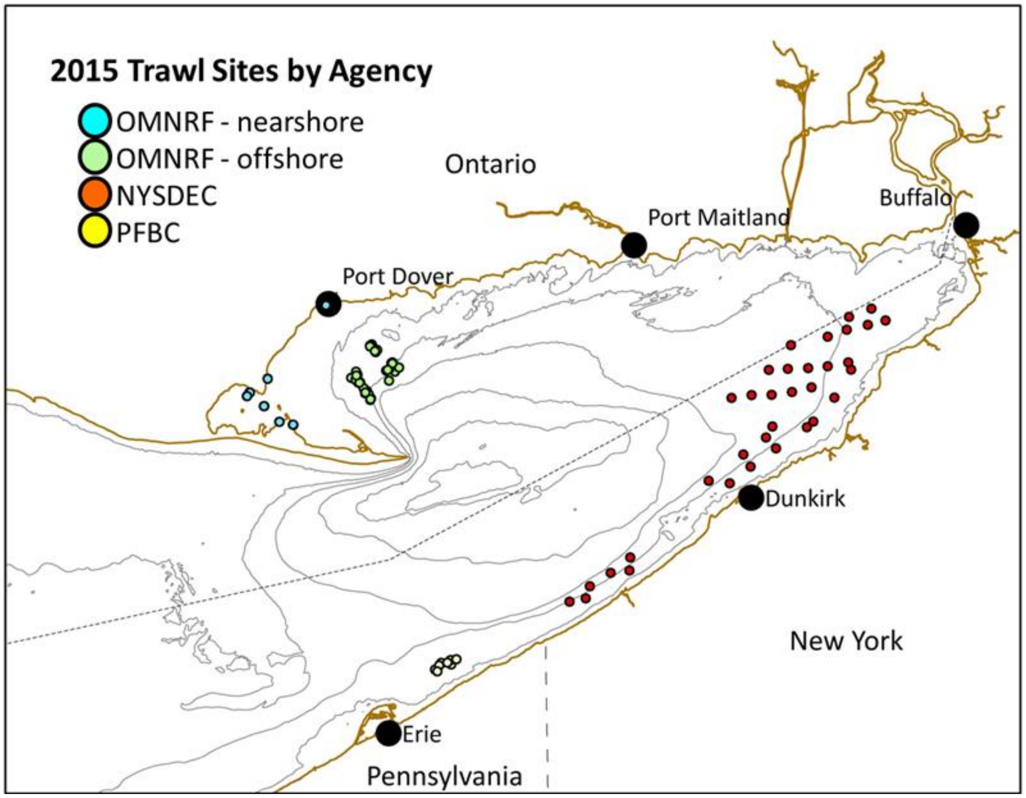

Figure 2.2.1 Locations sampled with standard index bottom trawls by Ontario (OMNRF), New York (NYSDEC) and Pennsylvania (PFBC) to assess forage fish abundance in eastern Lake Erie during 2015.

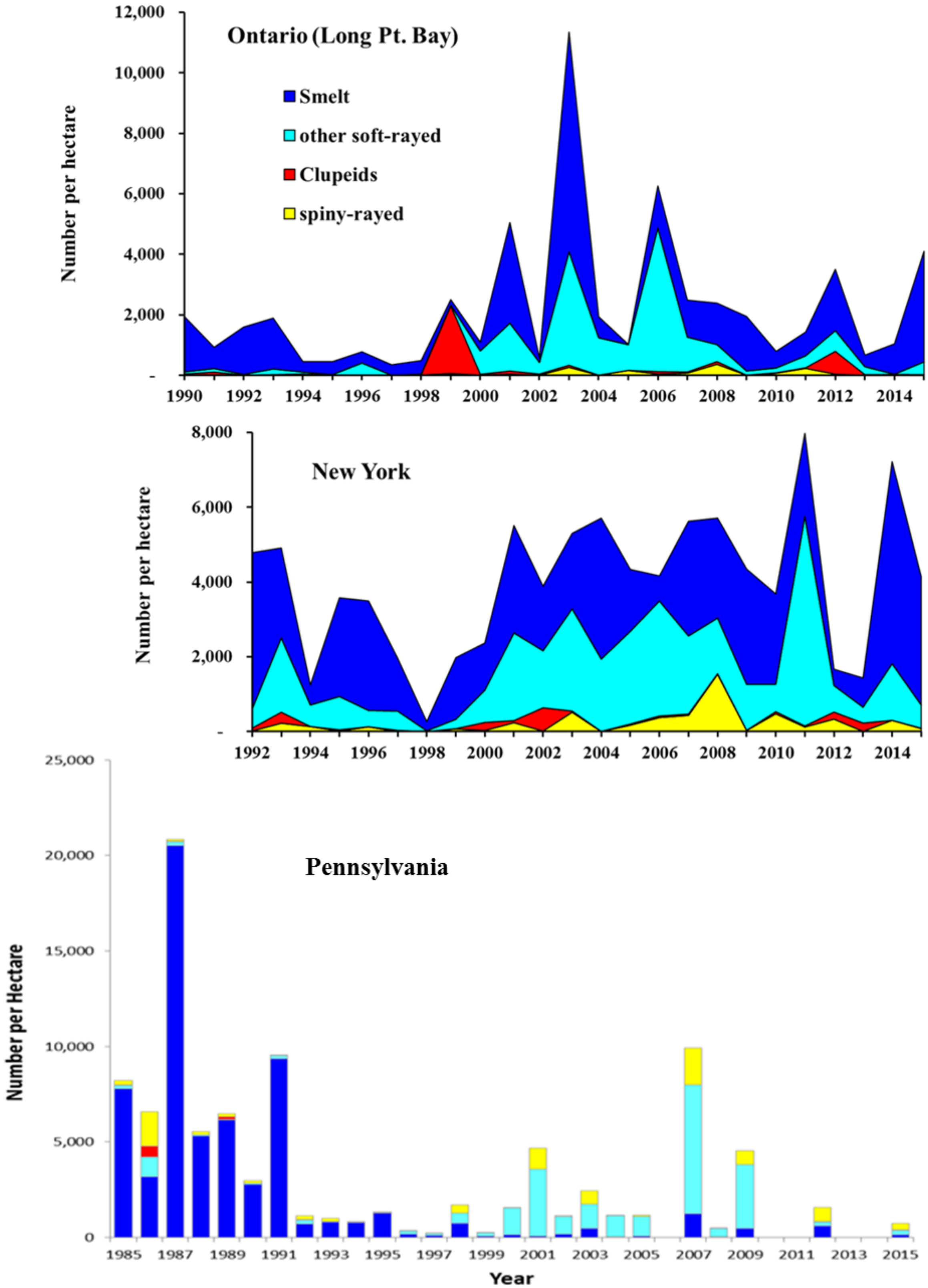

Figure 2.2.2 Mean density of prey fish (number/ha) by functional group in the Ontario, New York and Pennsylvania waters of the eastern basin, Lake Erie, 1985-2015.

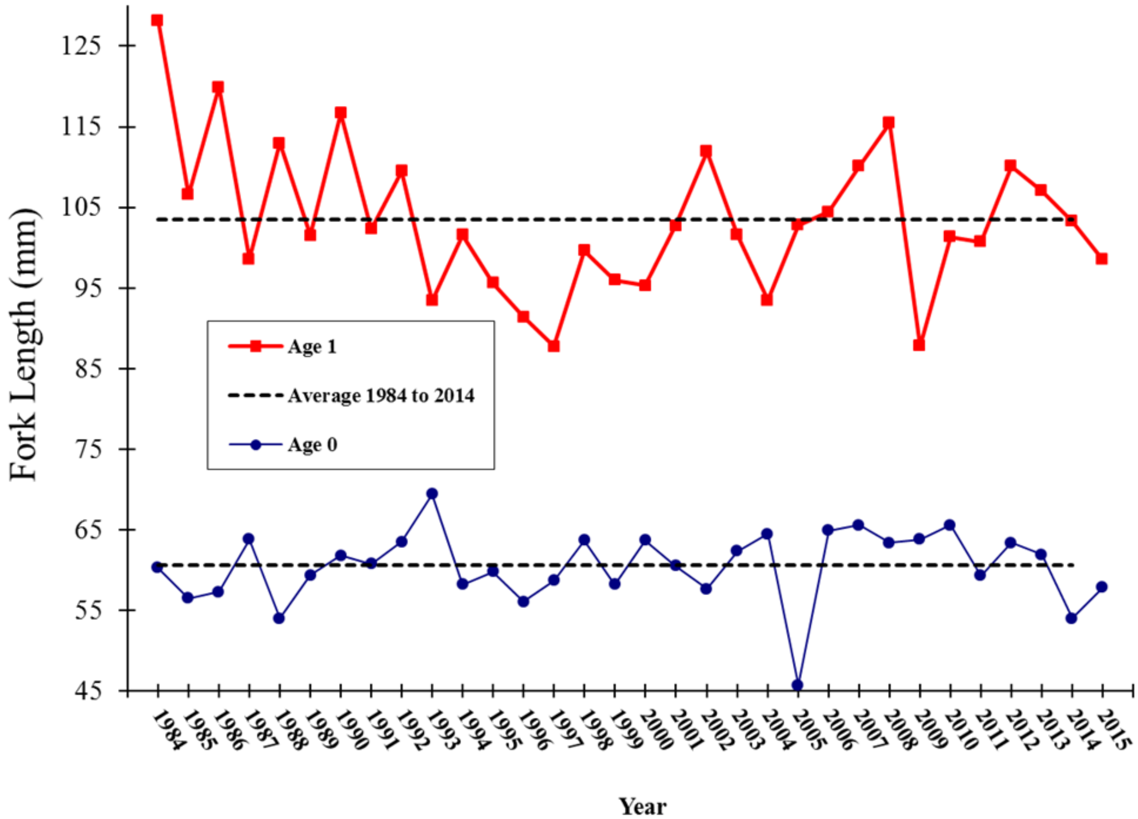

Figure 2.2.3 Mean fork length of age-0 and age-1 Rainbow Smelt from OMNRF index trawl surveys in Long Point Bay, Lake Erie, October 1984 to 2015.

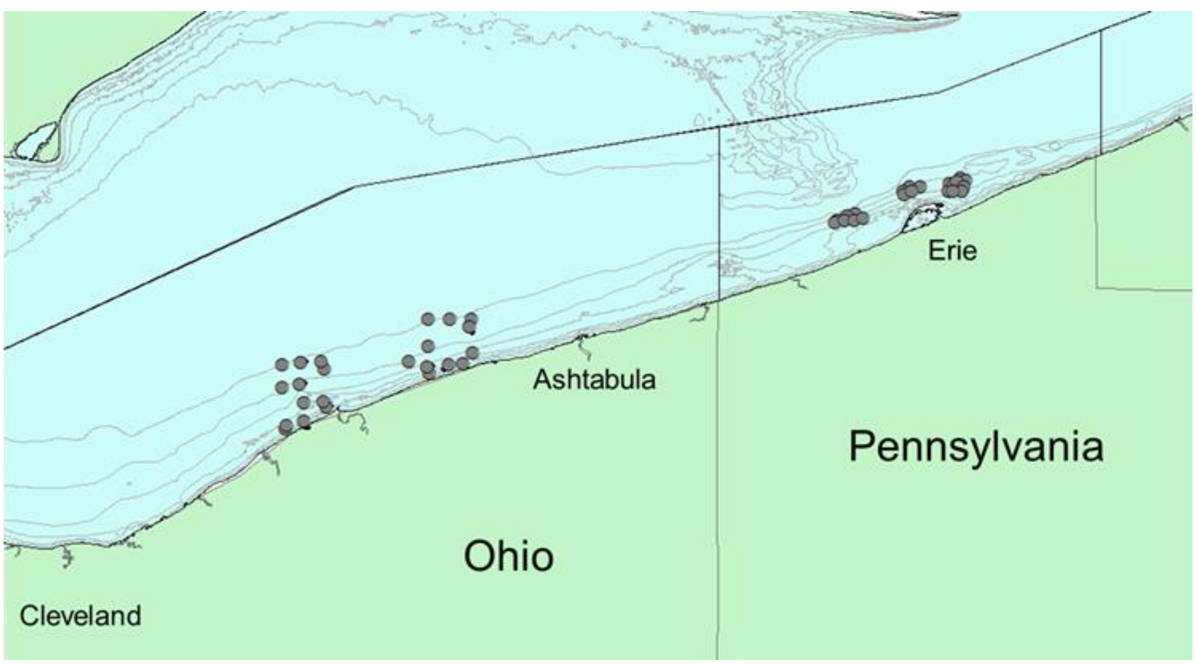

Figure 2.3.1 Locations sampled with index bottom trawls by Ohio (ODNR) and Pennsylvania (PFBC) to assess forage fish abundance in central Lake Erie during 2015.

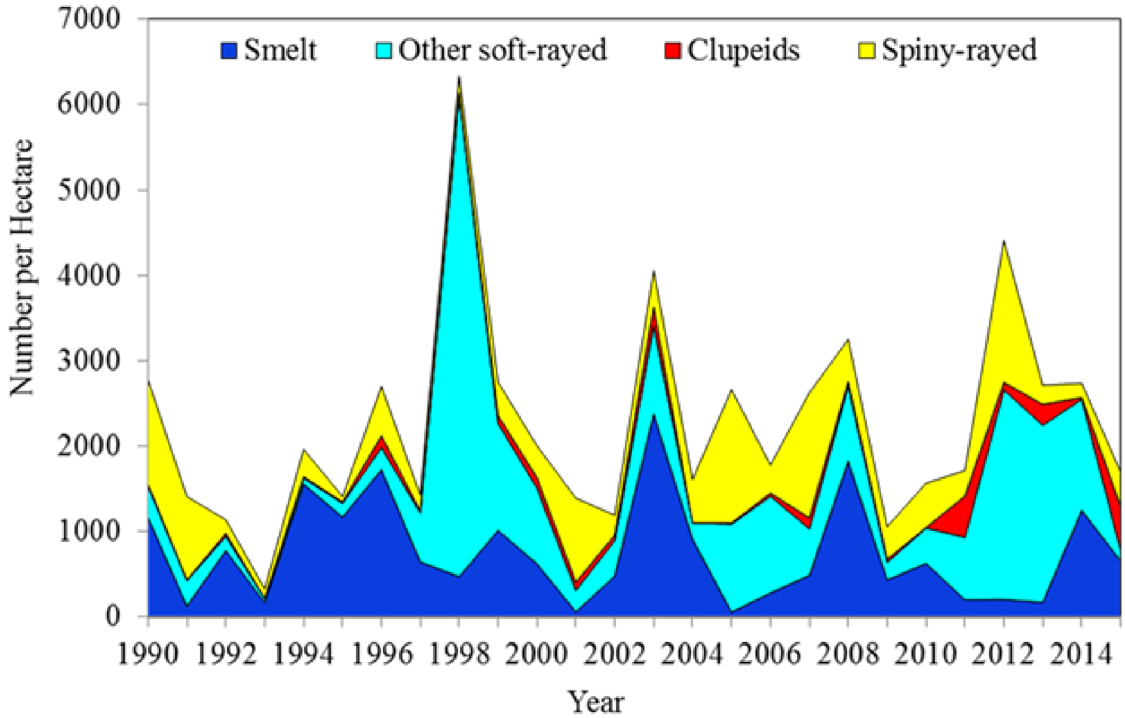

Figure 2.3.2 Mean density of prey fish (number per hectare) by functional group in the Ohio waters of the central basin, Lake Erie, 1990-2015.

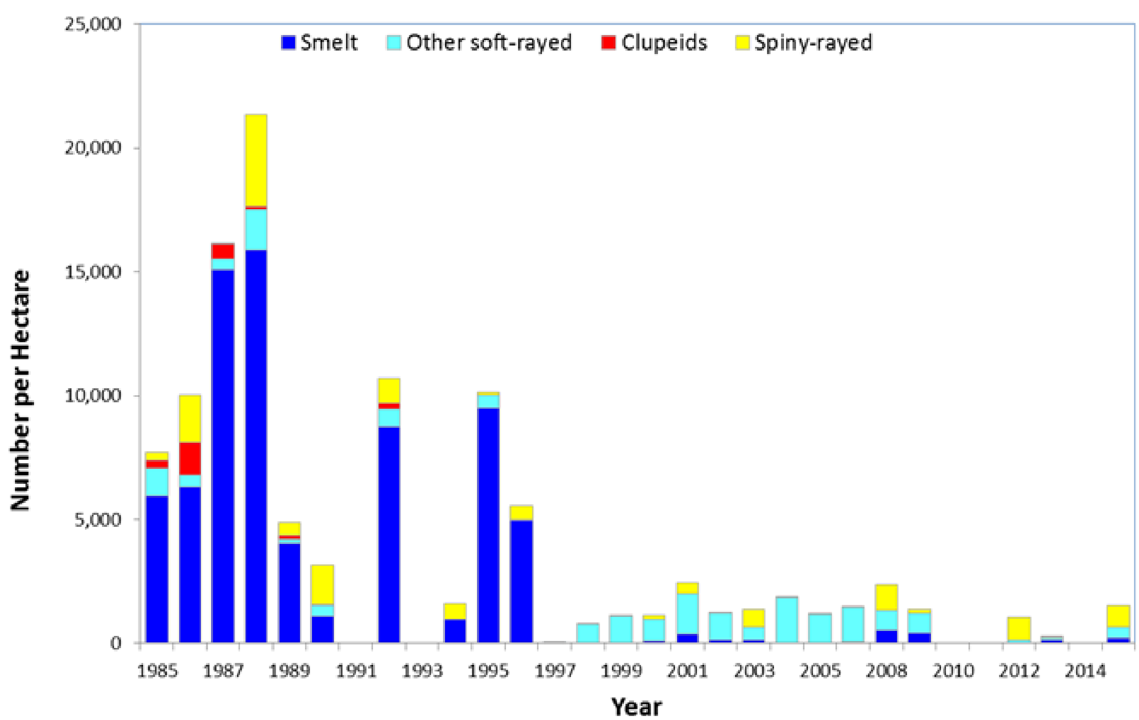

Figure 2.3.3 Mean density of prey fish (number per hectare) by functional group in the Pennsylvania waters of the central basin, Lake Erie, 1985-2015.

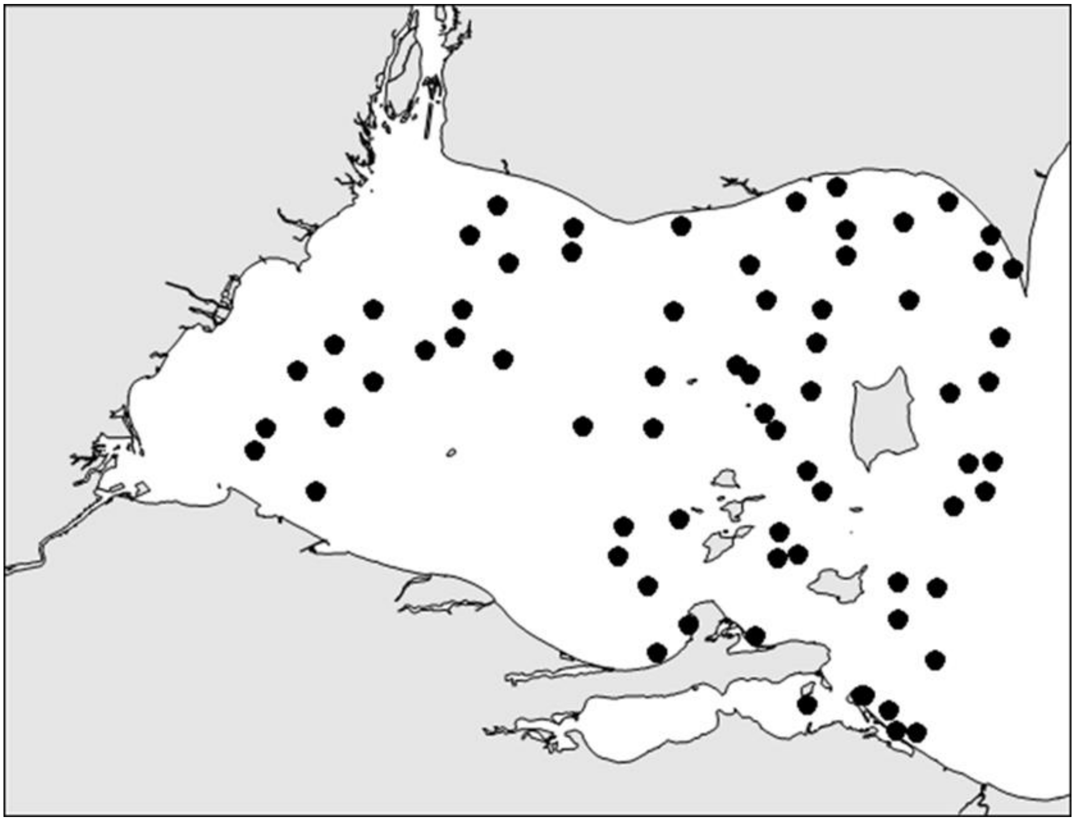

Figure 2.4.1. Trawl locations for the western basin interagency bottom trawl survey, August 2015

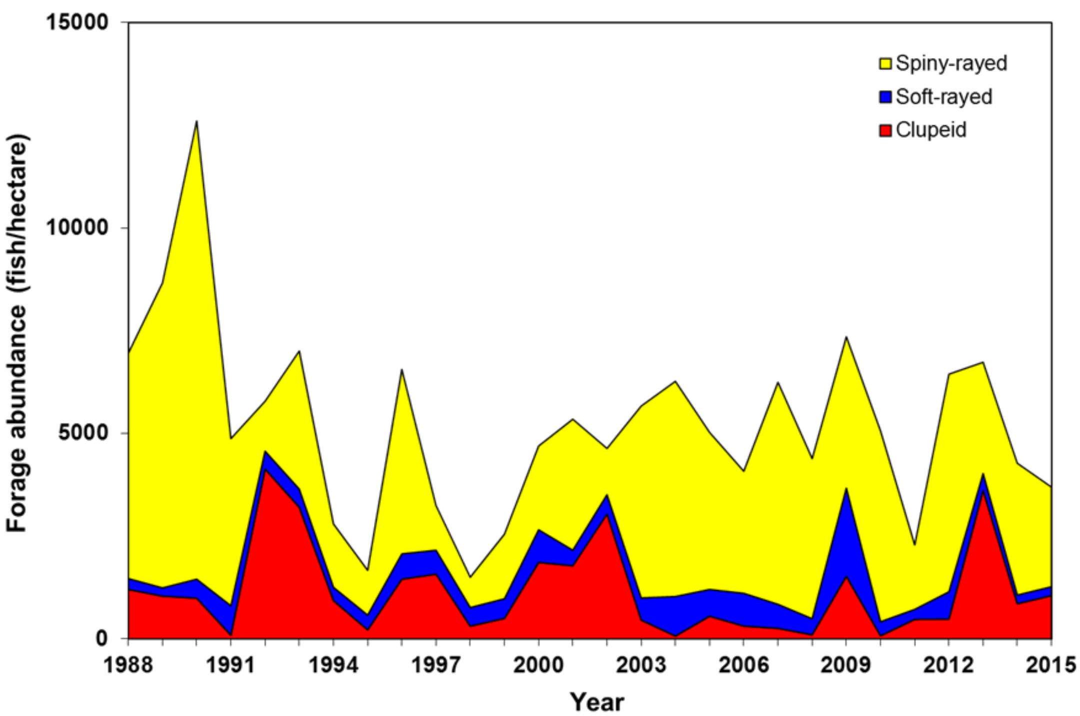

Figure 2.4.2. Mean density (number/ hectare) of prey fish by functional group in western Lake Erie, August 1988-2015.

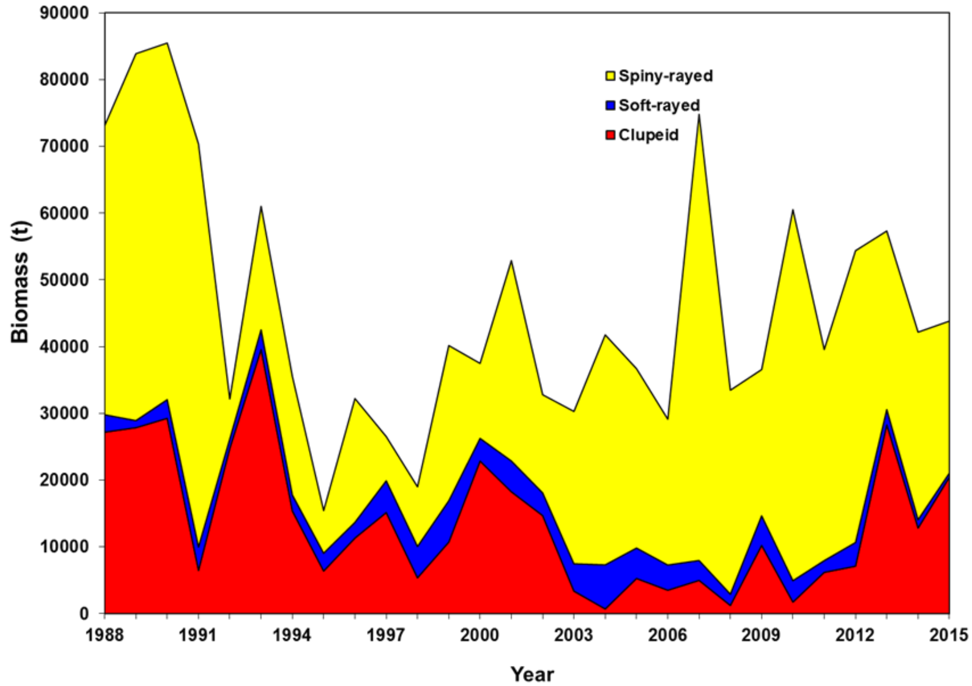

Figure 2.4.3. Mean biomass (tonnes) of prey fish by functional group in western Lake Erie, August 1988-2015.

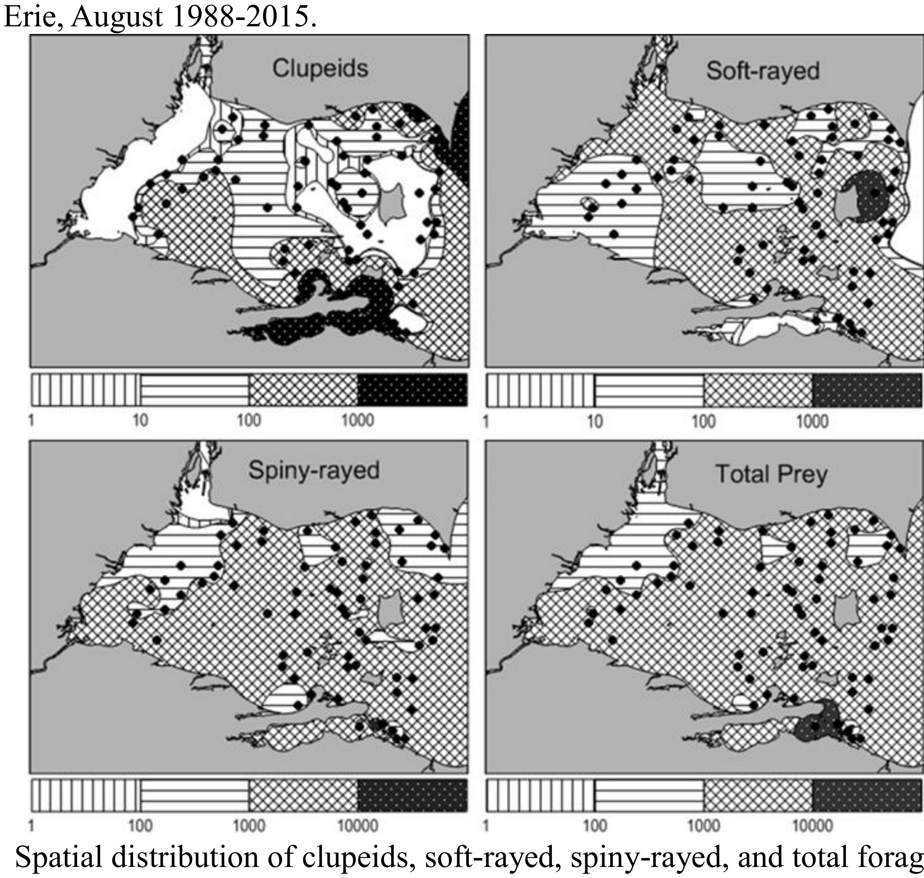

Figure 2.4.4. Spatial distribution of clupeids, soft-rayed, spiny-rayed, and total forage abundance (individuals per hectare) in western Lake Erie, 2015. Black dots are trawl sites, white areas are estimates of zero abundance, and contour levels vary with the each functional fish group.

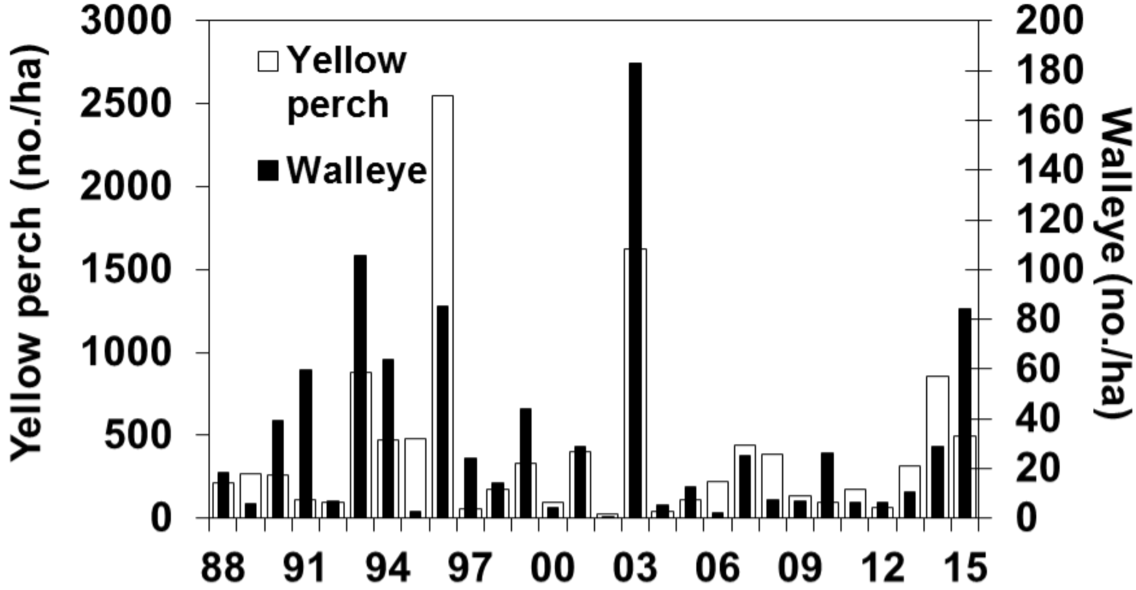

Figure 2.4.5. Density of age-0 Yellow Perch and Walleye in the western basin of Lake Erie, August 1988-2015.

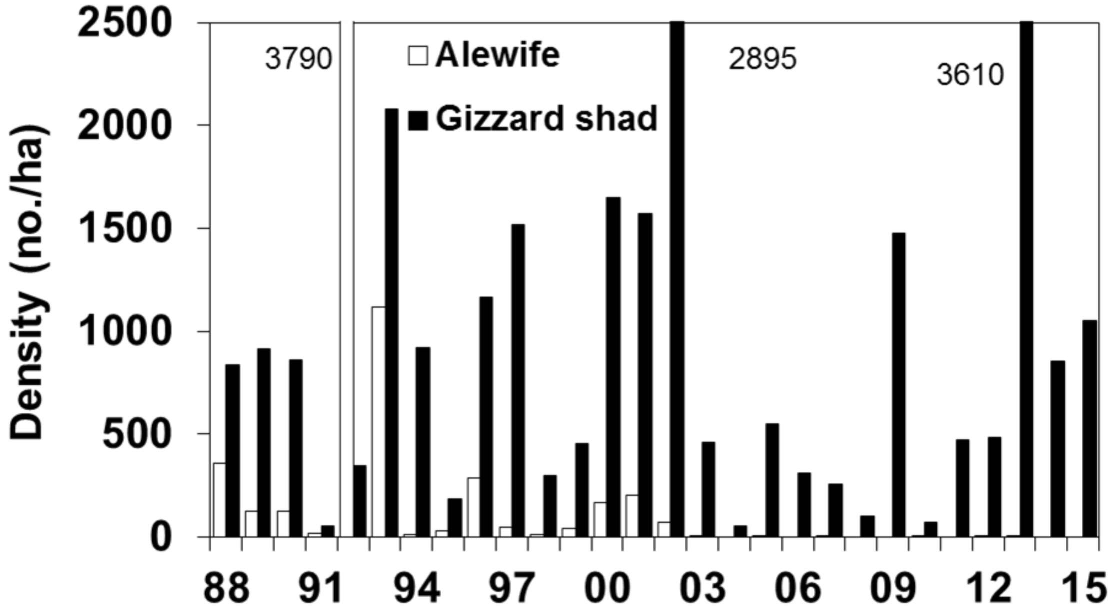

Figure 2.4.6. Density of age-0 Alewife and Gizzard Shad in the western basin of Lake Erie, August 1988-2015.

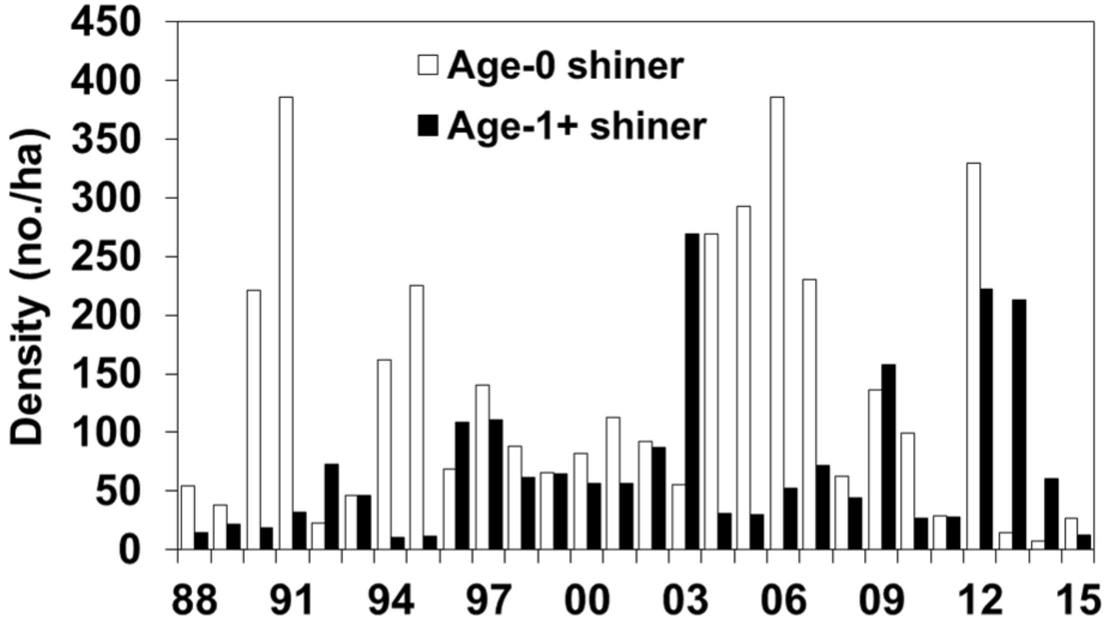

Figure 2.4.7. Density of age-0 and age-1+ shiners (*Notropis* spp.) in the western basin of Lake Erie, August 1988-2015.

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 Acoustic Survey (J .Trumpickas)

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 2014 edition of this report details the history, design and analytical methods of the hydroacoustic survey, as well as results up to the 2013 survey (Forage Task Group 2014).

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 starboard side of OMNRF's research vessel, R/V *Erie Explorer.* Hydroacoustic data were collected at 250 watts power output, 256 μsec pulse duration, and 3 per second ping rate. Precise navigation of survey transects was accomplished through an interface of the vessel's Global Positioning System (GPS) to a personal computer (PC) running marine navigation software (Nobeltec Navigation Suite ver7) and the ship's autopilot. The same GPS unit was also connected to a second PC running the Simrad ER60 software controlling the EY60 echosounder. Geo-referenced raw acoustic data were logged to 10-megabyte size files on the host PC.

The 2015 survey was designed with 12 randomly selected transects that were expected to take five nights to sample. The timing of the survey was centered on the July new moon (July 16 in 2015). Due to poor weather and boat issues, surveying only occurred on the nights of July 13-14 and July 15-16. The 6 central transects were completed over these two nights, totaling approximately 108 km (Figure 3.1.1). Hydroacoustic data collection occurred during darkness from approximately one-half hour after sunset to one-half hour before sunrise. A total of 620,000 KB of raw hydroacoustic data were collected while surveying transects, with an additional 64,000 KB of raw hydroacoustic data collected while stationary at the end of transects. The stationary data are collected to assess target strength (TS) variability of individual fish tracks. Water temperature-depth profiles were measured at the beginning and end of each surveyed transect. Water temperature data aid in the analysis of hydroacoustic data and the interpretation of fish distributions. In past years, NYSDEC conducted companion mid-water trawls to provide fish species identification data and to ground-truth fish sizes observed in hydroacoustic data. No companion netting was completed in 2015 because of problems with the NYSDEC vessel. Hydroacoustic data collected in 2014 and 2015 are currently awaiting analysis.

3.2 Central Basin Acoustic Survey (P. Kočovský and J. Deller)

The OMNRF, ODNR, and USGS have collaborated to conduct joint acoustic and midwater trawl surveys in central Lake Erie since 2004. In 2014 and again in 2015 we were not able to follow the established protocol and sample design (Forage Task Group 2005) due to hull and engine repairs to the ODNR R/V *Grandon.* In 2014 we were presented with the opportunity to run acoustic transects with the United States Environmental Protection Agency (USEPA) research vessel R/V *Lake Guardian* to assess fish avoidance of vessels during acoustic data collection (Forage Task Group 2015). In 2015 we were able to collect an additional transect of vessel comparison data between the R/V *Muskie* and R/V *North River*. In addition to the vessel comparison data, the R/V *Muskie* was able to collect three transects of hydroacoustic data in 2015. This resulted in four complete transects in the central basin survey. All data and analysis reported here are from the USGS R/V *Muskie*. All acoustic data were collected and analyzed following recommendations in the Standard Operating Procedures for Fisheries Acoustics Surveys in the Great Lakes (Parker-Stetter et al. 2009).

Hydroacoustics

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. Acoustics data were collected with BioSonics DTX® echosounders and BioSonics Visual Acquisition (release 6.0) software. Data from the R/V *Muskie* were collected using a 120-kHz, 8.2-degree, split-beam transducer mounted inside a through hull transducer tube at a depth of 1.5 m below the water surface.

Sound was transmitted at four pulses per second with each pulse lasting 0.4 milliseconds. Global Positioning System coordinates from the R/V *Muskie* were collected using a Garmin ® GPSMAP 76Cx and GPS coordinates were interfaced with the echosounders to obtain simultaneous latitude and longitude coordinates. Temperature readings from just above the thermocline were used to calculate speed of sound in water because the largest proportion of fish occurred nearest this depth in the water column. Because temperature is not uniform from surface to bottom, this necessarily results in slight error in estimated depth of fish targets. 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, we used a standard tungsten-carbide calibration sphere, specific to 120-kHz transducers, to calculate a calibration offset for calculating target strengths. Background noise was estimated by integrating beneath the first bottom echo for each transect.

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 6.1 software. Proportionate area backscattering coefficient and single targets identified using Single Target Detection Method 2 (Parker-Stetter et al. 2009) were used to generate density estimates for distance intervals. Distance intervals for each transect were 2 km. Depth strata were established based on similarity of distributions of single target strength. 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 threshold was -74 dB. This value permitted inclusion of all targets at least -68 dB within the half-power 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 estimated 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 nine 20-minute trawls on each of four transects in Ontario waters concurrent with the R/V *Muskie* acoustic data collection. Whenever possible, trawl effort was distributed above and below the thermocline to adequately assess species composition throughout the water column. The catch was sorted by species and age group, and relative proportions of each species and age group were calculated for each trawl. Age group was determined based on age-length keys and length distributions. Age group classifications consisted of age-0 for all species, age-1+ for forage species, and yearling (age-1) 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

Four complete cross-lake transects were sampled between 13 July and 17 July, 2015 with hydroacoustics and midwater trawls (Figure 3.2.1). The remaining transects were not completed due to vessel repair of the R/V *Grandon*.

A total of 36 midwater trawls and were completed during the survey. Rainbow Smelt were the primary species caught in midwater trawls across all four transects (Table 3.2.1). Young-of-the-year Rainbow Smelt was the predominant species caught in most midwater trawls (n=26). Yearling-and-older Rainbow Smelt was the primary species caught in the remaining trawls (n=9). Other species caught in midwater trawls included age-0 Emerald Shiner, Gizzard Shad and Yellow Perch; age-1 and age-2+ White Bass and White Perch; and age-2+ Walleye and Freshwater Drum.

Acoustic TS distributions, by depth, showed differences in TS across depth strata. As in previous years, depth layers were determined from TS-depth distributions in 2015. Highest acoustic densities occurred in the upper depth layers relative to the lower layer of each transect (Table 3.2.2). Species and age group composition of the trawl catch tended to separate by depth, except for the eastern most transect (57350) where age-0 Rainbow Smelt were caught throughout the water column. Yearling-and-older Rainbow Smelt densities were generally higher in the trawls fished deeper than 13 m on the three remaining transects. The highest densities of Emerald Shiner were in the upper layer, on the two western transect (57600, 57350).

Spatial distribution across transects varied by species and age group. Emerald Shiners were located in the shallow water nearest the Ontario shoreline (Figure 3.2.2). Young-of-the-year Rainbow Smelt tended to be uniformly distributed across the basin, with the exception of transect 57600, where densities were highest nearshore in Ontario (Figure 3.2.3). Yearling-and-older Rainbow Smelt densities were highest on two transects (58100 and 57600) on the southern half of each transect (Figure 3.2.4).

Hydroacoustic density estimates for Emerald Shiner were the lowest in the last five years and have been generally declining since 2011 (Figure 3.2.5). Rainbow Smelt age-0 and age-1+ estimates have increased from 2014 and are at the highest densities since 2011. The 2015 age-0 density estimate is almost four times larger than the previously high estimate in 2013.

Temperature and dissolved oxygen profiles collected concurrently with midwater trawls did not find any areas of low oxygen. The lowest oxygen level recorded during the survey was 3.7 mg/L on transect 57350 off Erieau, Ontario. Based on target distributions from whole-transect echograms, and past experience that highest densities of targets tended to be near the thermocline, the thermocline depth was relatively stable on individual transects in 2015 (Figure 3.2.6).

Temperature and dissolved oxygen profiles collected by the R/V *Keenosay* during the acoustic survey support the thermocline patterns on the echograms.

Discussion

Temperature and dissolved oxygen profiles did not find any areas of low oxygen that would affect the distribution of species in the water column. Thermocline depth was also more stable and consistent with historic patterns compared to the large fluctuations in thermocline depth on individual transects encountered in 2014. In most years, there is a strict pattern of large and small targets separated by the thermocline. The more consistent thermocline pattern encountered in 2015 would suggest that species composition and hydroacoustic target size would separate around the thermocline. However, the partition between large and small targets in acoustic data was not as obvious as in the past as smaller targets were frequently encountered below the thermocline. Historically, trawl catches also reflect the acoustic pattern, with larger species (age-1+ Rainbow Smelt) being caught almost exclusively below the thermocline. In 2015, age-0 Rainbow Smelt were caught throughout the water column on all four transects, which suggests a large cohort. Hydroacoustic density estimates of age-0 Rainbow Smelt were the largest in the last five years. Hydroacoustic densities of age-1+ Rainbow Smelt were similar to previous years, while Emerald Shiners were noticeably absent from the survey. Emerald Shiner densities were at their lowest levels in the 5 year time series, possibly a result of predation by large populations of age-0 Walleye and adult White Bass.

Hydroacoustics has been used to assess forage fish in central Lake Erie for approximately 13 years. The current design of hydroacoustic data collection in central Lake Erie includes 8 north- to-south-oriented, cross-lake transects between the 10-m depth contours. Ideally two hydroacoustic vessels each collect data along 4 transects, paired with two additional vessels using midwater trawls to collect fish specimens to identify fish species and relative abundances. The stated objective of the survey is to produce a basin-wide snapshot of abundance of pelagic species, primarily Rainbow Smelt and Emerald Shiner. Surveys have been conducted during the new moon phase in July. Sampling is conducted during the new moon because of effects of moonlight on diel vertical migration of Rainbow Smelt, which is in response to movements of prey in response to light level.

Since 2004 we have typically not achieved designed sampling objectives. Given the operational constraint of sampling in July nearest the new moon as possible, we are temporally limited to a 16-day window of opportunity from first to third-quarter moons. Four (if the new moon is on a weekday) or five (if new moon is on a weekend day) days within that window are automatically lost to weekends, and Canadian or US federal holidays have fallen within the window of opportunity in five years. Weather further constrains operations. Cross-lake transects take all night to complete at speeds that result in quality hydroacoustic data (i.e., acceptably low background noise), and it is exceptionally rare to have 4-5 consecutive days of suitable seas (suitable is in terms of quality of data – we are physically capable of sampling in rougher seas, but data are of poor quality). During the past decade we have sampled all 8 prescribed cross-lake transects only once (2005).

In addition to these operational constraints, there has never been a rigorous analysis of sampling strata in central Lake Erie. The original design considered the area between the 10 m contours as a homogenous stratum. That assumption has not been rigorously examined. The design also excludes sampling areas closer to shore, which was done out of consideration for draft of the larger vessels used for hydroacoustics. This is a potentially great liability to assessing abundance and distribution of walleye forage species.

Our chronic operational problems with completing the designed survey and apparent shortcomings with respect to providing relevant data for fisheries management have led us to the conclusion that an evaluation of the design and conduct of the central basin hydroacoustics program is warranted. The principal science/management question is: what are relevant sampling strata? We intend to use the last 10 years' of trawl data from the R/V *Keenosay*, R/V *Musky II*, and R/V *Grandon* to identify sampling strata for key species. Based on past efforts in the Great Lakes we intend to use ordination and clustering methods to discover strata using the following variables: water depth, sampling depth (from surface and bottom), distance from shore, latitude, and longitude as predictors (at a minimum). A geographic information system will then be used to estimate areas within sampling strata to allocate effort within strata. Results of this evaluation will be merged with results of our evaluation of vessel avoidance (Forage Task Group 2015) to design the next generation hydroacoustic survey.

3.3 West Basin Acoustic Survey (E. Weimer)

Since 2004, the Ohio Department of Natural Resources Division of Wildlife has been conducting 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 companion trawling has been conducted in conjunction with acoustic data collection since 2006.

Methods

Three fixed cross basin transects were planned for the survey in 2015. All transects were surveyed using a BioSonics DE-X surface unit belonging to the Michigan Department of Natural Resources' (MDNR) Lake St. Clair Fisheries Research Station. The continued issues with the Lake Erie BioSonics DT-X surface unit remains troubling. Plans to test the unit on the Inland Research unit acoustic survey boat (to determine whether the Lake Erie survey vessel is generating electrical interference) during the fall were postponed due to scheduling issues. We intend on re-scheduling this test in the spring. As of now, the surface unit has been replaced by BioSonics, so further testing will focus on the transducers and cables. Regardless of the outcome of this testing, it is encouraging to have access to functional hydroacoustic survey equipment, and we thank the MDNR for the loan of their equipment and will plan on using it for surveys in the future.

Data was collected in 2015 using a single, downward-facing, 7.5-degree, 123-kHz split-beam transducer, a Garmin GPS, and a Panasonic CF-30 laptop computer. The acoustic system was calibrated before the survey with a tungsten carbide reference sphere of known acoustic size. The mobile survey, conducted aboard the ODNR's *RV Almar*, was initiated 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 kph using the GPS. The transducer was mounted on a fixed pole located on the port side of the boat amidships, one meter below the surface. Data were collected using BioSonics Visual Acquisition 5.0.4 software. Collection settings during the survey were 10 pings per 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 a 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 4.5 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):

$$\text{Total length} = 10^{((\text{Target Strength} + 26.1)/19.1) * 1000}$$

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

Results

In 2015, three cross-basin transects were surveyed July 13, 20 and 22, 2015, with the southern half of the middle transect missed due to declining sea state (Figure 3.3.1). One hundred twenty-one km of Lake Erie were surveyed, resulting in the collection of 1.4 gb of data. Western basin forage fish density and biomass estimates were high in 2015, averaging 54,309 fish per hectare and 22 kg per hectare, respectively (Figure 3.3.2). Forage fish densities were highest along the eastern transect. Statistical testing (ANOVA) indicated that density in 2015 was significantly higher than in previous surveys ($F_{8, 985} = 66.4$, $P < 0.0001$). Biomass in 2015 was higher than in 2005, 2011, and 2008, while lower than in 2007 and 2013 ($F_{8, 985} = 40.2$, $P < 0.0001$). Fish were small in 2015, with nearly all (98%) forage fish in the survey estimated to be between 20-69 mm.

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, 2015.

Transect	Trawl ID	Depth	Layer	Latitude	Longitude	Emerald Shiner all ages	Rainbow Smelt age-0	Rainbow Smelt Age 1+	Other species[1] all ages
58100	1009	7	Upper	42.6215	-81.0038	0.0	27.0	72.8	0.2
58100	1003	8	Upper	42.3983	-80.9223	0.0	95.5	4.5	0.0
58100	1008	8	Upper	42.6192	-81.0037	0.2	95.0	3.3	1.5
58100	1007	10	Upper	42.5527	-80.9850	0.0	99.1	0.3	0.6
58100	1006	13	Upper	42.5662	-80.9893	0.0	99.5	0.5	0.0
58100	1002	15	Lower	42.4127	-80.9230	0.0	24.5	75.5	0.0
58100	1005	16	Lower	42.5500	-80.9810	0.0	98.6	0.7	0.7
58100	1001	19	Lower	42.3957	-80.9167	0.0	9.0	91.0	0.0
58100	1004	19	Lower	42.4217	-80.9172	0.0	14.3	79.4	6.3
57850	2009	7	Upper	42.5638	-81.4712	1.7	68.6	25.0	4.7
57850	2003	8	Upper	42.3497	-81.3725	0.0	98.8	0.0	1.2
57850	2007	8	Upper	42.4870	-81.4410	0.0	98.8	0.0	1.2
57850	2008	10	Upper	42.5625	-81.4747	0.2	44.9	54.4	0.4
57850	2006	12	Upper	42.4848	-81.4367	0.0	94.0	2.4	3.6
57850	2002	16	Lower	42.3443	-81.3793	0.0	43.5	55.9	0.6
57850	2005	17	Lower	42.4867	-81.4442	0.0	56.8	35.1	8.1
57850	2004	19	Lower	42.3432	-81.3723	0.0	3.9	96.1	0.0
57850	2001	20	Lower	42.3407	-81.3715	0.0	58.5	41.5	0.0
57600	3007	6	Upper	42.2113	-81.8028	0.4	98.7	0.0	0.9
57600	3009	6	Upper	42.2750	-81.8157	22.9	68.3	5.9	2.8
57600	3004	8	Upper	42.0992	-81.7297	0.0	94.8	1.7	3.5
57600	3008	8	Upper	42.2657	-81.8287	34.5	56.0	6.7	2.8
57600	3003	13	Upper	42.0792	-81.7465	0.0	5.2	94.1	0.7
57600	3006	15	Lower	42.2015	-81.8027	0.2	97.4	0.5	1.8
57600	3002	17	Lower	42.0593	-81.7417	0.0	2.4	97.6	0.0
57600	3005	18	Lower	42.2075	-81.8068	0.0	94.6	1.7	3.7
57600	3001	22	Lower	42.0767	-81.7443	0.0	4.5	94.7	0.8
57350	4004	6	Upper	41.9158	-82.1538	0.0	92.1	0.0	7.9
57350	4009	7	Upper	42.1423	-82.2533	0.7	81.4	0.0	17.8
57350	4007	8	Upper	42.0320	-82.2042	0.0	98.9	0.3	0.9
57350	4003	10	Upper	41.9132	-82.1513	0.0	93.3	0.0	6.7
57350	4008	11	Upper	42.1462	-82.2602	10.6	75.7	0.0	13.7
57350	4006	13	Lower	42.0368	-82.2040	0.0	99.3	0.0	0.7
57350	4002	14	Lower	41.9123	-82.1543	0.0	93.8	1.6	4.6
57350	4005	18	Lower	42.0332	-82.2138	0.0	88.3	1.9	9.8
57350	4001	19	Lower	41.9098	-82.1542	0.0	91.3	6.1	2.6

1 Other species (age, N captured): Freshwater Drum (Adult, 59); Gizzard Shad (YOY, 4); Walleye (adult, 1); White Bass (YOY, 21, Age 1+, 30); White Perch (YOY, 12, Age 1+, 11); Yellow Perch (YOY, 60).

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 2015. 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.

Age Group	Species	58100 Upper	Lower	57850 Upper	Lower	57600 Upper	Lower	57350 Upper	Lower
Age-0	Rainbow Smelt	15846	544	31316	1294	7394	847	29599	7156
Age 1+	Rainbow Smelt	482	3403	415	926	15372	3882	20	387
All ages	Emerald Shiner	2	0	23	0	428	1	158	0
All ages	Other species	39	4	533	34	227	21	2118	325

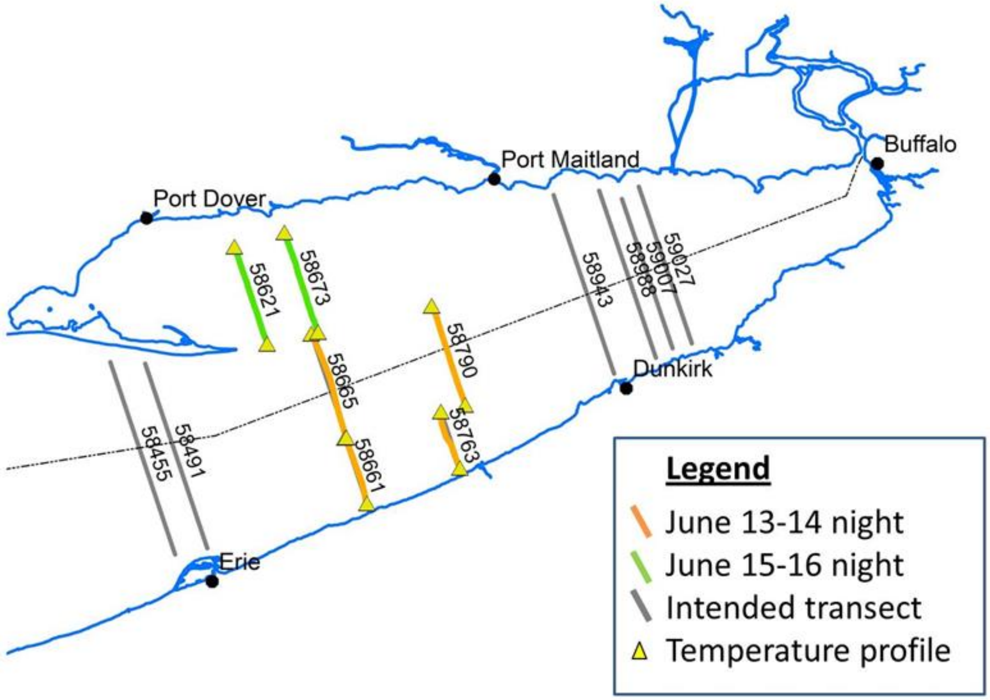

Figure 3.1.1. July 2015 eastern basin Lake Erie inter-agency acoustic survey transects and temperature profile sites sampled by the Ontario Ministry of Natural Resources (OMNRF) research vessel, RV *Erie Explorer*.

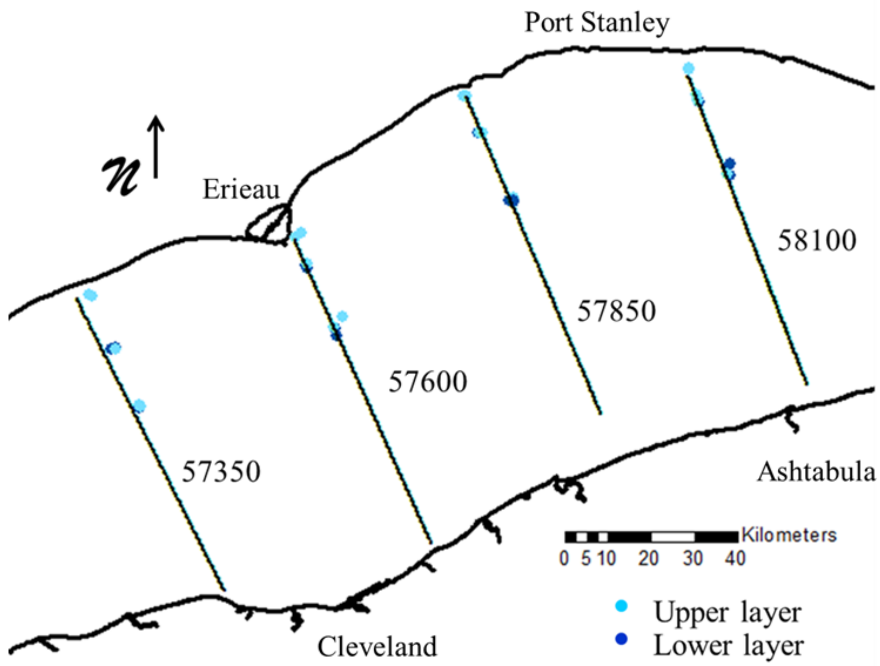

Figure 3.2.1 Hydroacoustic transects and midwater trawling stations in the central basin, Lake Erie, July 13-17, 2015. Transect numbers are Loran-TD lines.

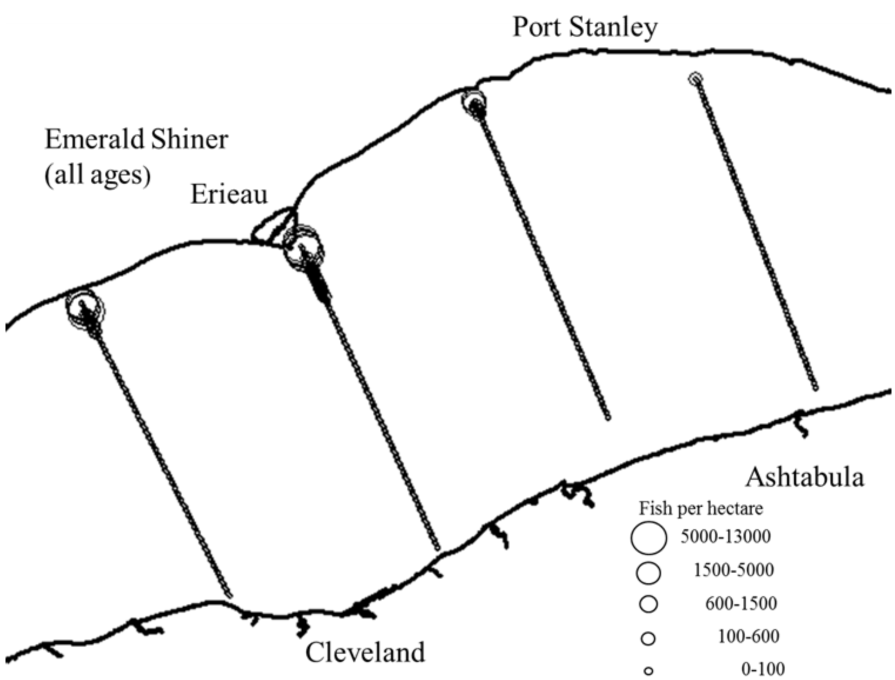

Figure 3.2.2. Density estimates of Emerald Shiner (fish/ha) per distance interval along hydroacoustic transects in the central basin, Lake Erie. Distance intervals were 2 km segments to ensure adequate numbers of single targets for *in-situ* analysis. Transects are Loran-TD lines sampled in 2015.

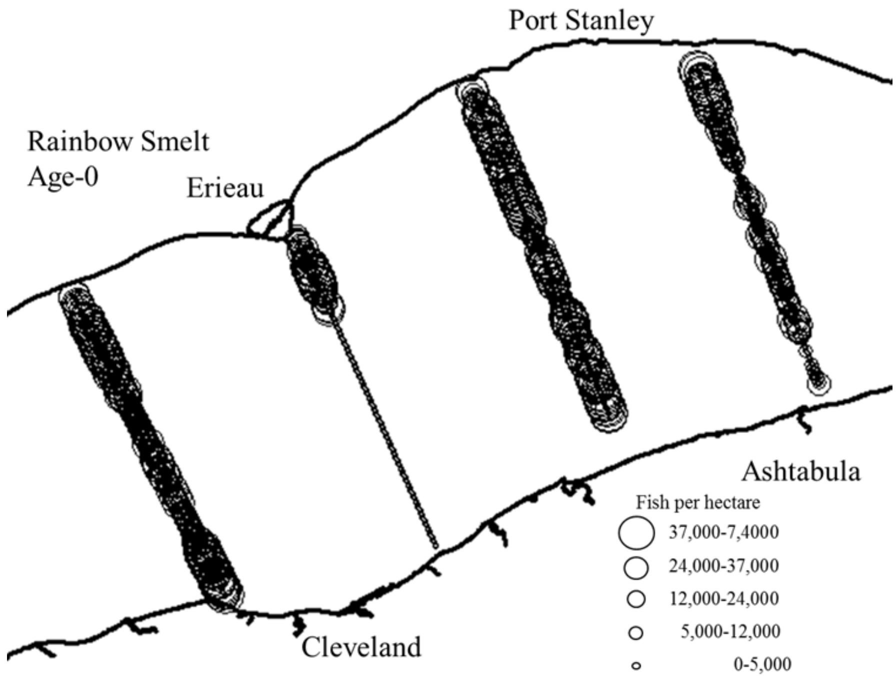

Figure 3.2.3. Density estimates of age-0 Rainbow Smelt (fish/ha) per distance interval along hydroacoustic transects in the central basin, Lake Erie. Distance intervals were 2 km segments to ensure adequate numbers of single targets for *in-situ* analysis. Transects are Loran-TD lines sampled in 2015.

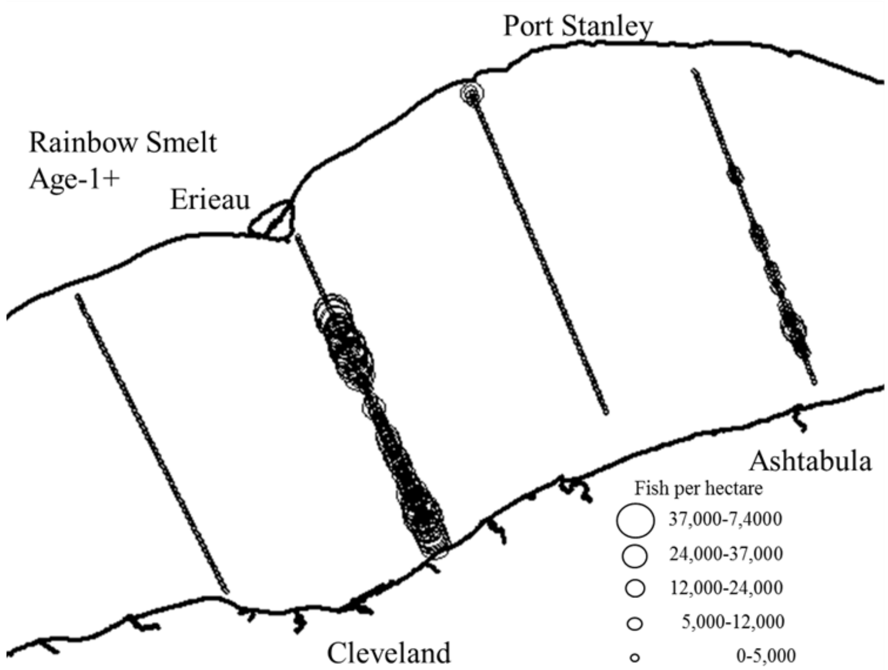

Figure 3.2.4. Density estimates of age-1+ Rainbow Smelt (fish/ha) per distance interval along hydroacoustic transects in the central basin, Lake Erie. Distance intervals were 2 km segments to ensure adequate numbers of single targets for *in-situ* analysis. Transects are Loran-TD lines sampled in 2015.

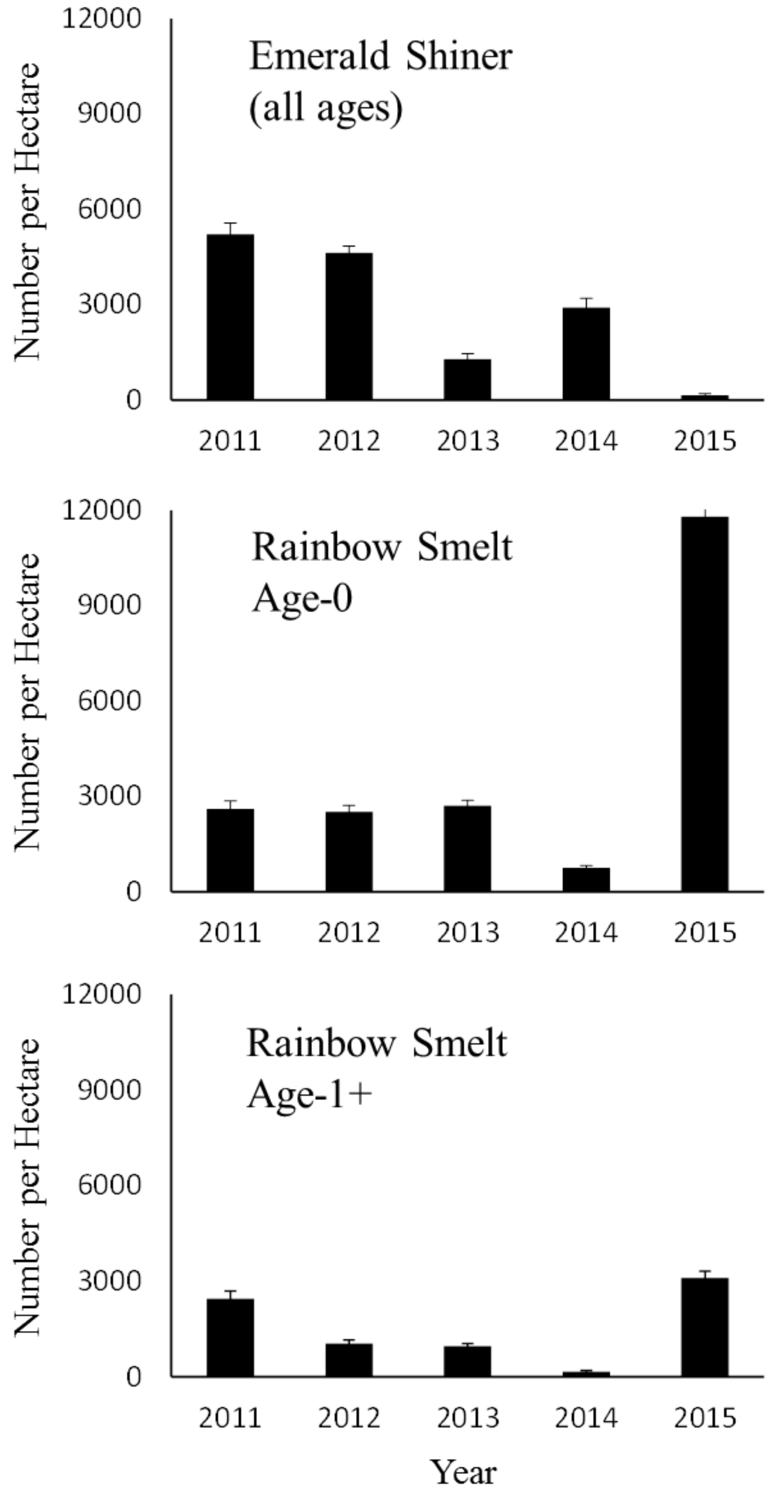

Figure 3.2.5. Mean density (Number per hectare) estimates of pelagic forage fish during the July central basin, Lake Erie hydroacoustic survey, 2011-2015.

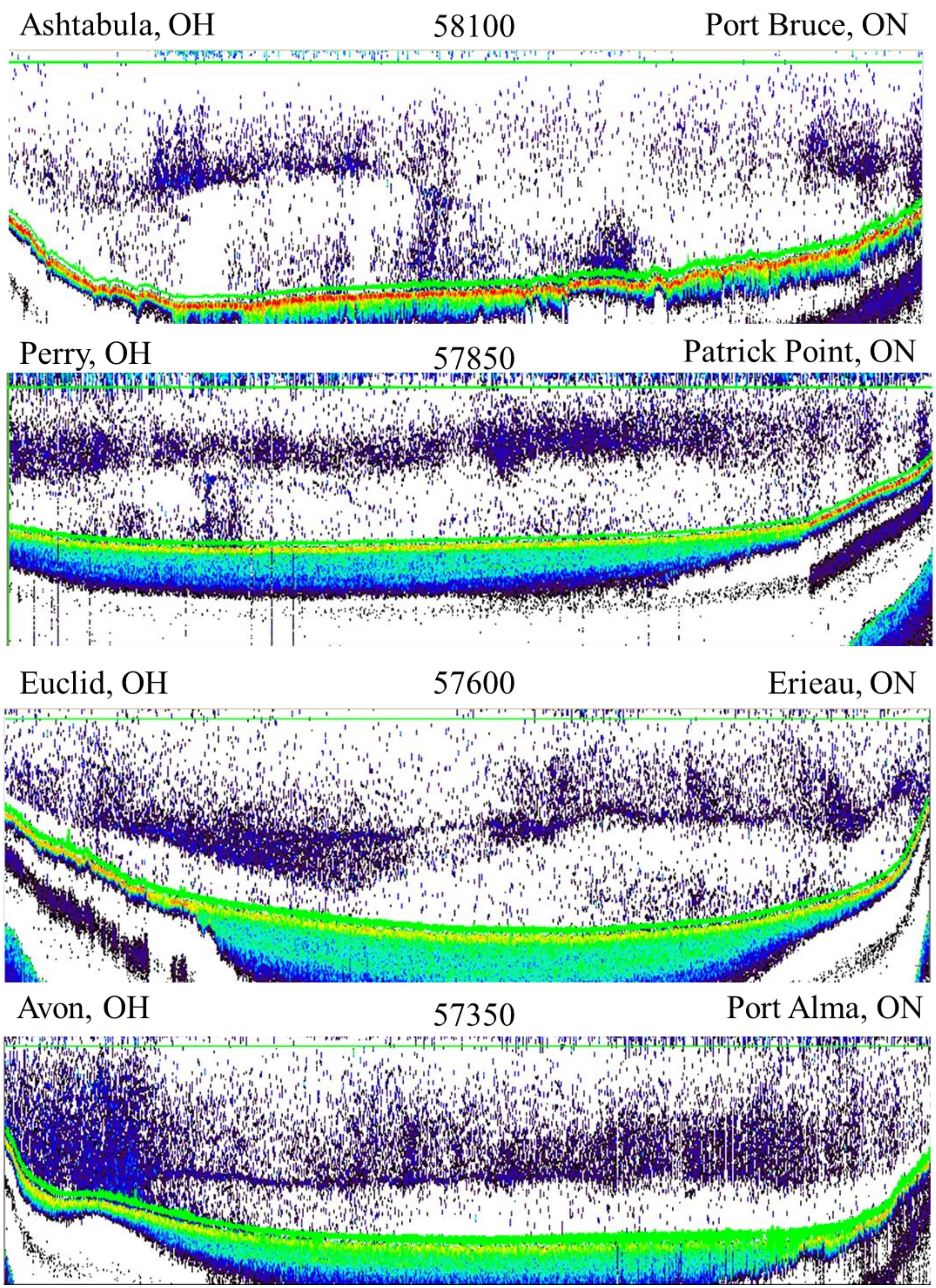

Figure 3.2.6. Echogram files generated from Echoview® software version 6.1 that show total back scattering (Sv) along transects in the central basin, 2015.

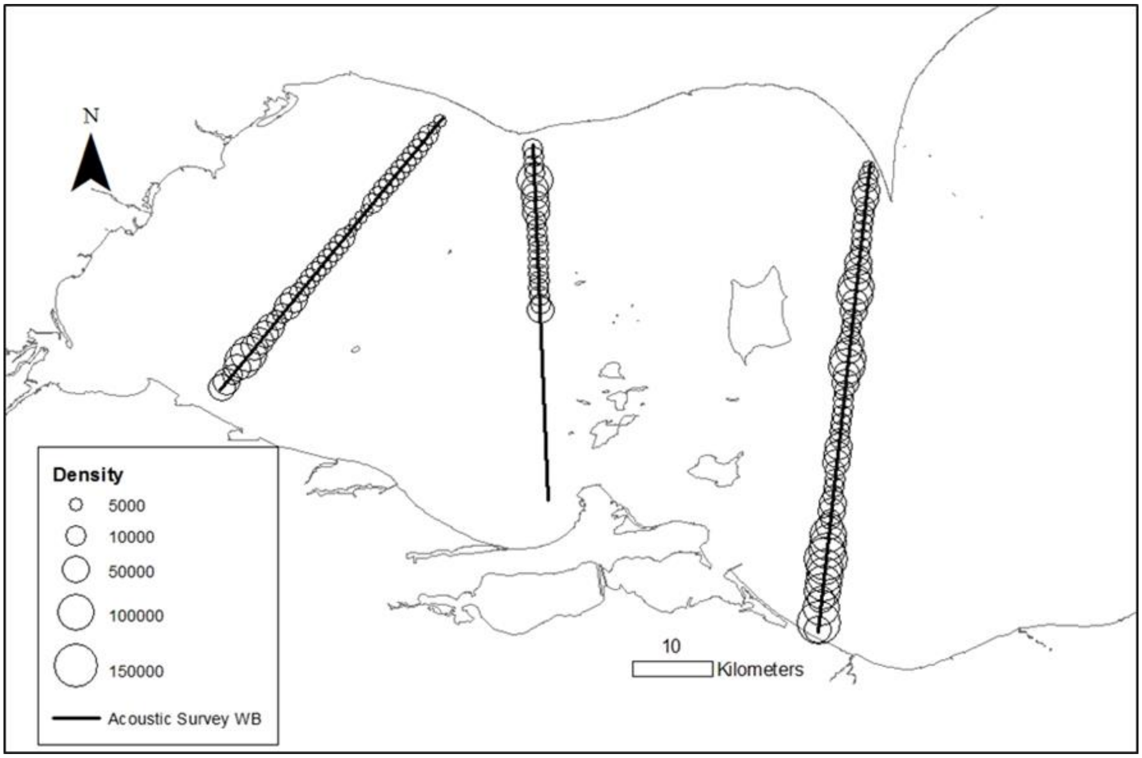

Figure 3.3.1. Acoustic survey transects and associated density (Number/ha) for the western basin of Lake Erie, 2015.

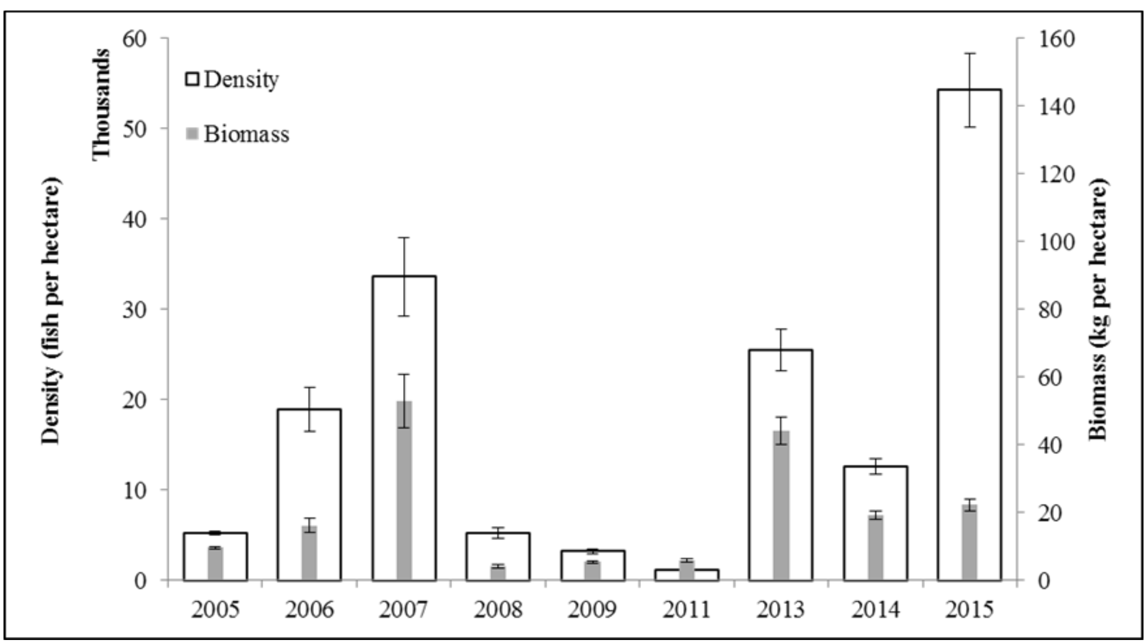

Figure 3.3.2. Mean density (number/ha) and biomass (kg/ha) estimates from the western basin acoustic survey, 2005-2015. Estimates are for acoustic targets between -60dB and -38dB. Error bars are standard errors.

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. Trumpickas and J. Markham)

Beginning in 1993, intermittent, 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. The number of Walleye stomachs examined annually has varied from a high of 409 in 2000 to a low of 34 in 2004. The percent of non-empty stomachs ranged from 57% in 1995 to 19% in 2000. During 2015, 247 Walleye stomachs were examined of which 99 (40%) contained food remains. Throughout the time series, Rainbow Smelt represented the majority of the angler-caught adult Walleye diet (Figure 4.1.1). Infrequently, mayfly nymphs (*Hexagenia* spp.) were observed in June and early-July stomach samples during the earlier half of the time series, but they have not been encountered since 2003. In 2015 samples, the contribution by volume of identifiable species included four fish species: Rainbow Smelt (51%), Round Goby (27%), Trout sp. (20%), and Emerald Shiner (3%). Also found in some Walleye stomachs were small, nearly unquantifiable amounts of spiny water fleas (*Bythotrephes sp.)*. The most commonly occurring prey items found in Walleye diets from summer index gillnets in Long Point Bay (30 non-empty stomachs examined) during 2015 were Rainbow Smelt (occurred in 70% of stomachs), Round Goby (30%) and Emerald Shiner (10%).

Round Goby were first observed in the summer diet of Yellow Perch from Long Point Bay in 1997 and from New York waters in 2000. This invasive prey species has been present in 50% or more of non-empty Yellow Perch stomachs since 2008 in Long Point Bay diet studies, peaking at 83% occurrence in 2013 and then decreasing to the current level of 68% (2015; 203 non-empty stomachs examined) (Figure 4.1.2).

Round Goby have been the largest component of the diet of adult Smallmouth Bass caught in New York gillnet surveys since 2000. In Long Point Bay, Round Goby were first observed in the diet of Smallmouth Bass in 2001 and, since 2010, were present in 74 to 91% of non-empty bass stomachs examined (Figure 4.1.2).

Fish species continue to comprise the majority of the diets of both Lake Trout and Burbot caught in experimental gillnet surveys during August in the eastern basin of Lake Erie. Rainbow Smelt have been the dominant food item in Lean strain Lake Trout since coldwater netting surveys began in the early 1980s in Lake Erie, occurring in 85-95% of the stomachs. However, in years of low age-1+ Rainbow Smelt abundance, such as 2006 and 2010, Round Goby became prominent in the diets of both Lean and Klondike strain Lake Trout. During 2015, 726 Lean strain Lake Trout and 60 Klondike strain Lake Trout stomachs were examined, of which 521 (72%) Lean and 24 (40%) Klondike Lake Trout contained food remains. Rainbow Smelt were the dominant forage species, occurring in 98% of Lean strain and 91% of Klondike strain non-empty stomach samples (Figure 4.1.3). Round Goby were the next most abundant diet item, occurring in 6% and 4% of the samples for Lean strain and Klondike strain, respectively. White Perch (0.2%) and Yellow Perch (0.6%) were the only other identifiable fish species found in 2015, and these were in Lean strain Lake Trout. Round Goby have occurred more frequently in the diets of Klondike than Lean strain Lake Trout during most years that Klondike trout have been collected in coldwater index gill nets.

Round Goby have increased in the diet of Burbot since this invasive species first appeared in Lake Erie's eastern basin in 1999, replacing Rainbow Smelt as the main prey item in Burbot diets in eight of the last 15 years (Figure 4.1.4). In 2015, Round Goby (67%) were the most common fish species found in non-empty Burbot stomachs followed by Rainbow Smelt (29%). Emerald Shiners (4%) and Yellow Perch (4%) were the only other identifiable fish species found in 2015 samples. In general, Burbot appear to have a more diverse diet than Lake Trout over this time series. It should be noted that samples sizes for Burbot diets have been below 30 fish since 2013.

Growth

Mean length of age-2 and age-3 Smallmouth Bass cohorts sampled in 2015 autumn gill net collections (New York) have remained stable over ten years and are among the highest in the 34-year history of this survey. Beginning in the late 1990's, roughly coincident with the arrival of Round Goby, Smallmouth Bass in Long Point Bay, Ontario, exhibited a trend of increasing length-at-age (Figure 4.1.5). Following a peak in size-at-age for the older age classes in 2008, there has been a moderate decreasing trend in size-at-age of Smallmouth Bass (Figure 4.1.5).

Walleye length at age-1 in 2015 from netting surveys targeting juveniles in New York were similar to 2014 and the long-term average. No age-2 Walleye were captured in 2015. In general, age-0 and age-1 Yellow Perch have exhibited stable growth rates over the past ten years. Length-at-age of age-1 to age-6 Yellow Perch were above the time-series average (1986-2014) in Ontario's Long Point Bay gillnet assessments in 2015. Mean size-at-age (length and weight) of Lake Trout in 2015 were consistent with the recent 10-year average (2005 – 2014) and condition coefficients (K) remain high. Klondike strain Lake Trout have significantly lower growth rates compared to Lean strain Lake Trout. Lake Trout growth in Lake Erie continues to be stable and among the highest in the Great Lakes.

4.2 Central Basin (J. Deller)

Diets of adult Walleye are collected from the central basin fall gillnet survey in Ohio waters. In 2015, 109 non-empty stomachs were examined and analyzed for diet composition. Gizzard shad comprised over 84% (by dry weight) of Walleye diets, followed by Emerald Shiner (8.8%) and Rainbow Smelt (3%) (Figure 4.2.1).

Round Goby continue to comprise the bulk of Smallmouth Bass Diets in the central basin. In 2015, Round Goby accounted for 54.6% of Smallmouth Bass diets by dry weight (Figure 4.2.2). This was the lowest consumption rate by Smallmouth Bass in a 5 year time series. In 2012, Round Goby comprised over 40% of Adult Yellow Perch diets. Round Goby contribution to Yellow Perch diets has declined over the last three years and is currently less than 5%.

Central basin age-0 Gizzard Shad trawl indices were some of the largest in the last decade. The exceptional cohort is contributing to Smallmouth Bass and White Bass diets. In fall diets, age-0 Gizzard Shad accounted for 34% of Smallmouth Bass and White Bass diets. This is the largest percentage for Smallmouth Bass and second largest for White Bass in a 5 year time series of diet composition.

Growth

Growth rates of most age-0 predator and forage species in 2015 were above average (10 years, 2005-2014). Only Walleye and Gizzard Shad were below average, most likely an effect of the exceptional cohorts of each species in 2015. Mean length of age-1 and age-2 Walleye collected in Ohio's fall gillnet survey in 2014 have declined since 2012, and are below average. Mean size-at-age for Yellow Perch remains above average through age-5. White Bass mean length was similar to or above average for age-1 and age-2.

4.3 Western Basin (E. Weimer and P. Kočovský)

In 2015, adult Walleye diets (by frequency of occurrence) taken from ODNR fall gillnet catches consisted of Gizzard Shad (87%), Emerald Shiners (2.5%), White Perch (2.5%), and unidentifiable fish remains (8%) in the western basin. Yearling Walleye relied on Gizzard Shad (85%), Emerald Shiner (1%),

and unidentifiable fish remains (14%). Age-0 Walleye relied on Gizzard Shad. Similarly, MDNR fall index gillnet walleye stomachs were dominated by Gizzard Shad and Emerald Shiners.

Age-2-and-older yellow perch were collected for diet content analysis from the western basin during spring (June) and autumn (September) by the U.S. Geological Survey. In spring, benthic macroinvertebrates were present in the highest frequency of diets (63.0%). The occurrence of zooplankton in diets was 49.3% in spring, and increased to 82.8% in the autumn. Fish prey had an 8.2% occurrence in spring diets, and increased in occurrence to 24.7% in autumn diets. Ephemeridae (45.2%; exclusively *Hexagenia* spp.), Dreissenidae (27.4%), and Chironomidae (19.2%) were the most prominent benthic macroinvertebrates in spring, whereas Amphipoda (11.8%) was the most frequently encountered prey taxon in autumn diets. The most commonly found zooplankton prey in spring diets was Daphnidae (46.6%) and Leptodoridae (21.9%), and Cercopagididae (63.4%; exclusively *Bythotrephes* sp.) and Daphnidae (31.2%) in autumn diets. The occurrence of fish prey greatly increased from spring to autumn (8.2% and 24.7% of diets, respectively) with round goby (5.5% and 3.2%, respectively) being the most common identifiable prey type in both seasons. There were two observed invasive *Hemimysis* sp. and no invasive *Cercopagis* sp. identified in yellow perch diets from the western basin in 2015. Comparisons to historical data collected in Michigan and Ontario waters suggest an increasing trend in frequency of occurrence in zooplankton prey for spring and autumn yellow perch diets.

Percent composition by dry weight revealed a pattern similar to the frequency of occurrence data for yellow perch diets. Benthic macroinvertebrates contributed most to yellow perch diets in spring (53.6%), followed by zooplankton (42.0%) and fish prey (4.4%). In spring, Ephemeridae (23.0%) and Dreissenidae (22.7%) were the predominant benthic macroinvertebrate contributors by weight. Our spring sampling coincided with an Ephemeridae hatching event and many stomachs appeared very full and only contained Ephemeridae. In autumn, zooplankton made the highest contribution to diets (63.0%), followed by fish prey (19.6%) and benthic macroinvertebrates (17.4%). The major zooplankton taxa contributor in autumn was Cercopagididae (51.8%). Gastropoda, Amphipoda, and Dreissenidae, which accounted for almost 100% of total benthic macroinvertebrate weight observed in diets. The major identifiable fish prey taxon contributor in autumn was Round Goby (1.5%). An increasing contribution of fish prey to yellow perch diets from spring to autumn is consistent with our historical observations.

Growth

Mean length of age-0 sport fish in 2015 declined compared to 2014 (Figure 4.3.1). Lengths of select age-0 species in 2015 include Walleye (133 mm), Yellow Perch (61 mm), White Bass (49 mm), White Perch (60 mm), and Smallmouth Bass (64 mm). These lengths are below or near long-term averages (139 mm, 67 mm, 67 mm, 58 mm, and 78 mm, respectively).

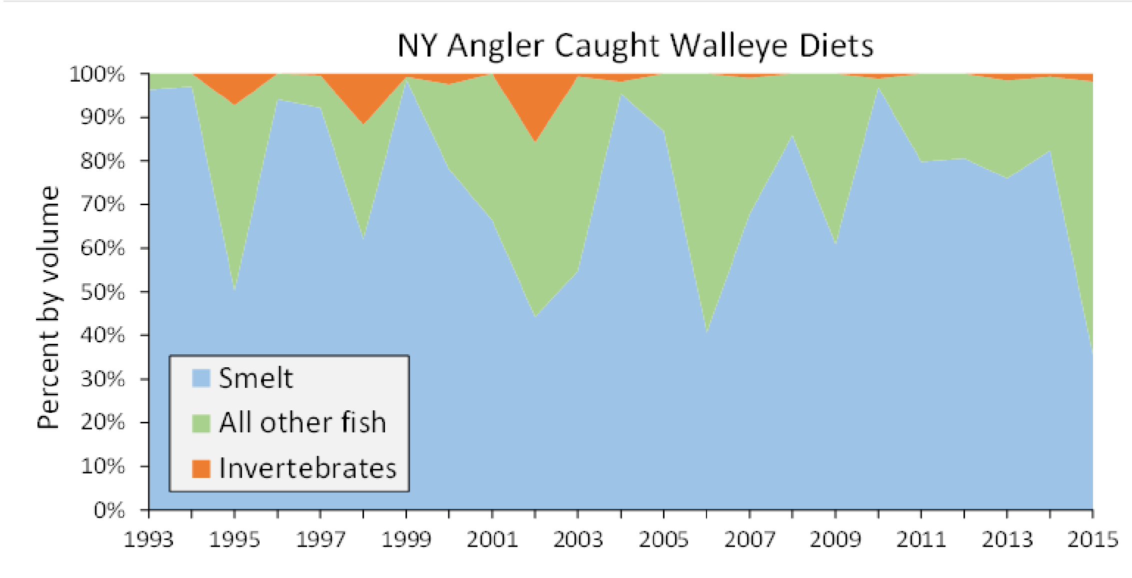

Figure 4.1.1. The percent contribution (by volume) of identifiable prey in stomachs of adult Walleye caught by summertime anglers in New York's portion of Lake Erie, 1993 to 2015.

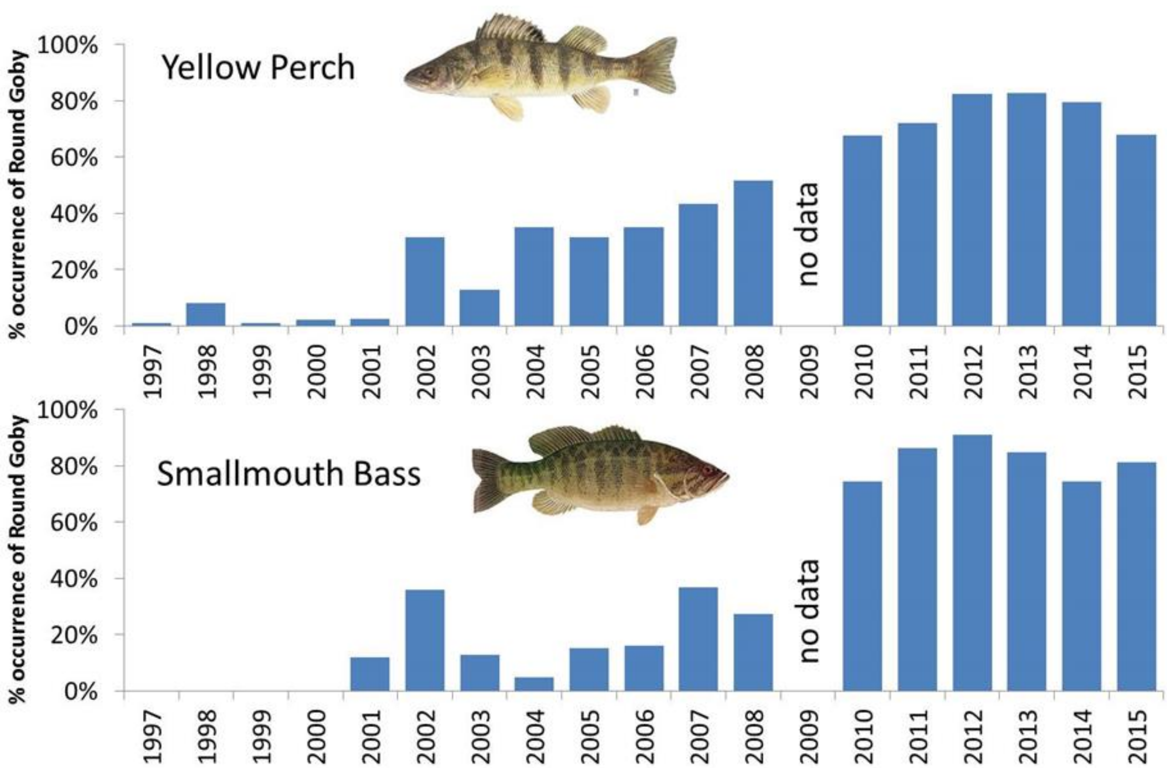

Figure 4.1.2. Percent occurrence of Round Goby in non-empty stomachs of adult Yellow Perch and Smallmouth Bass from OMNRF summer index gillnets, Long Point Bay, Lake Erie 1997 to 2015.

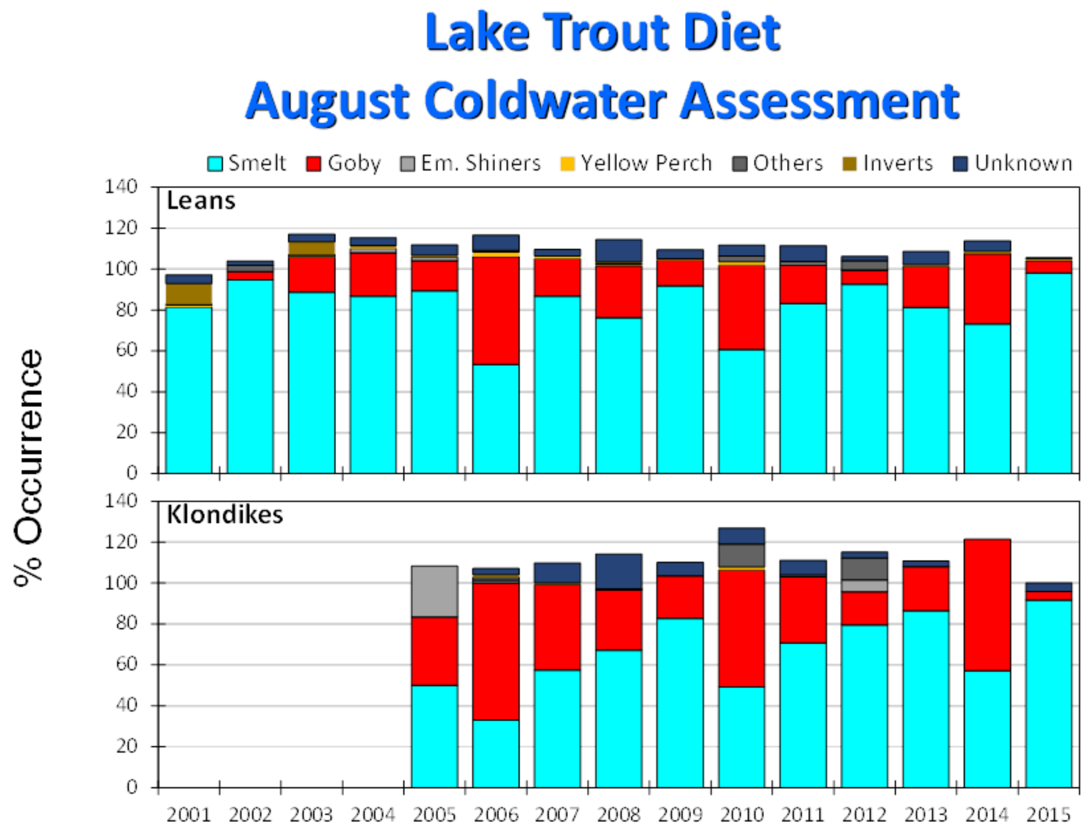

Figure 4.1.3. Percent occurrence of diet items from non-empty stomachs of Lean and Klondike strain Lake Trout collected in gill nets from eastern basin waters of Lake Erie, August 2001-2015.

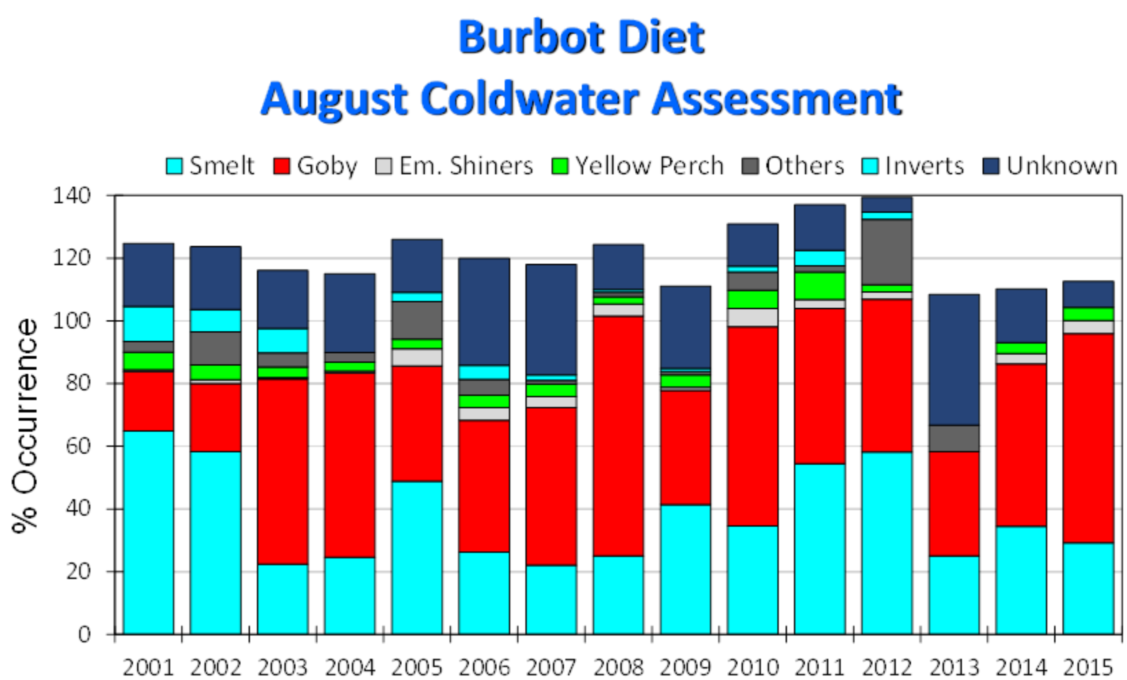

Figure 4.1.4. Percent occurrence of diet items from non-empty stomachs of Burbot collected in gill nets from eastern basin waters of Lake Erie, August, 2001 - 2015.

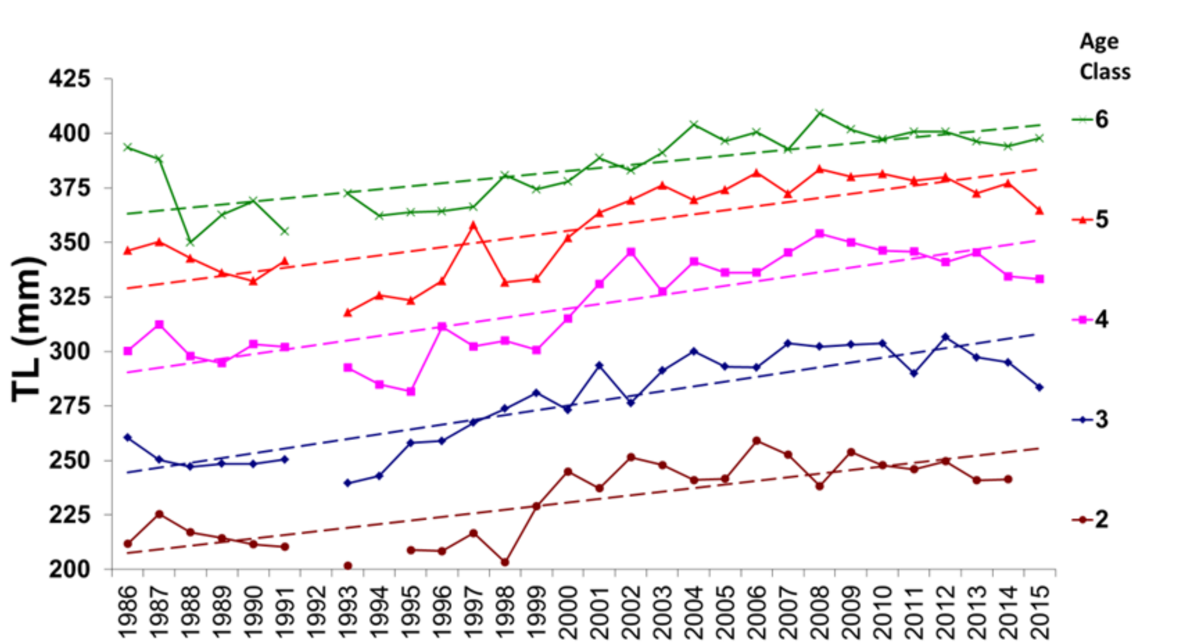

Figure 4.1.5. Smallmouth Bass mean total length (mm) at ages 2 to 6 captured in index gill nets set overnight at 12-30 ft. (3.7-9.1 m) depths during summer months in Long Point Bay, Lake Erie, 1986-2015. Males and females combined. Dashed lines represent linear trend across years for each age class. Smallmouth Bass ages were not available for 1992 samples.

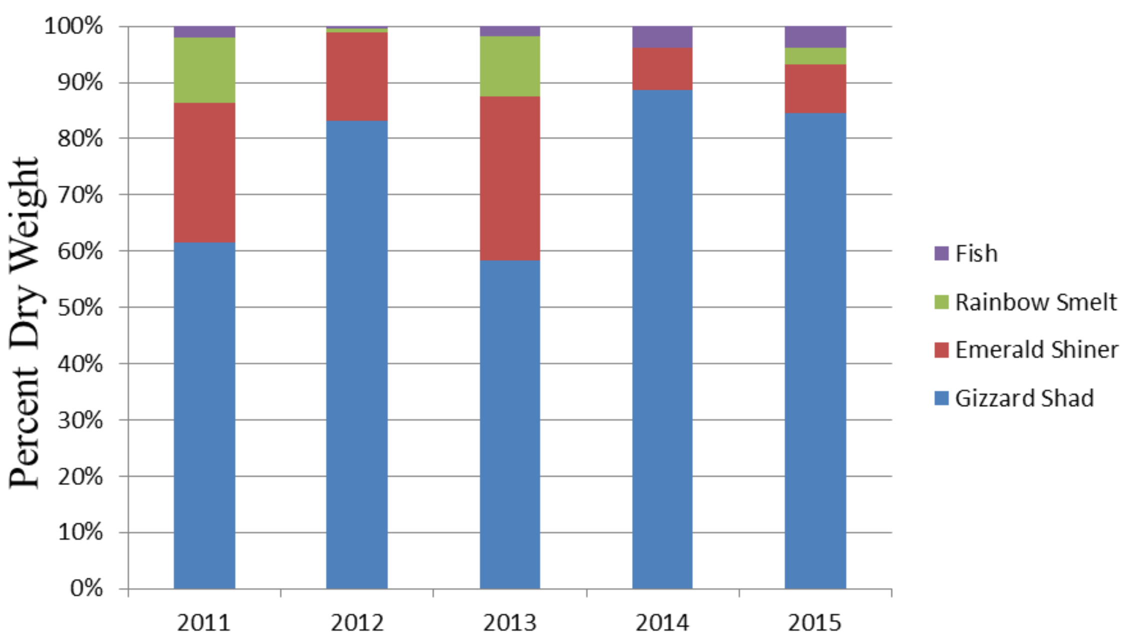

Figure 4.2.1. Adult Walleye diet composition (Percent dry weight) from non-empty stomachs collected in gill nets from central basin, Ohio waters of Lake Erie, 2011 - 2015.

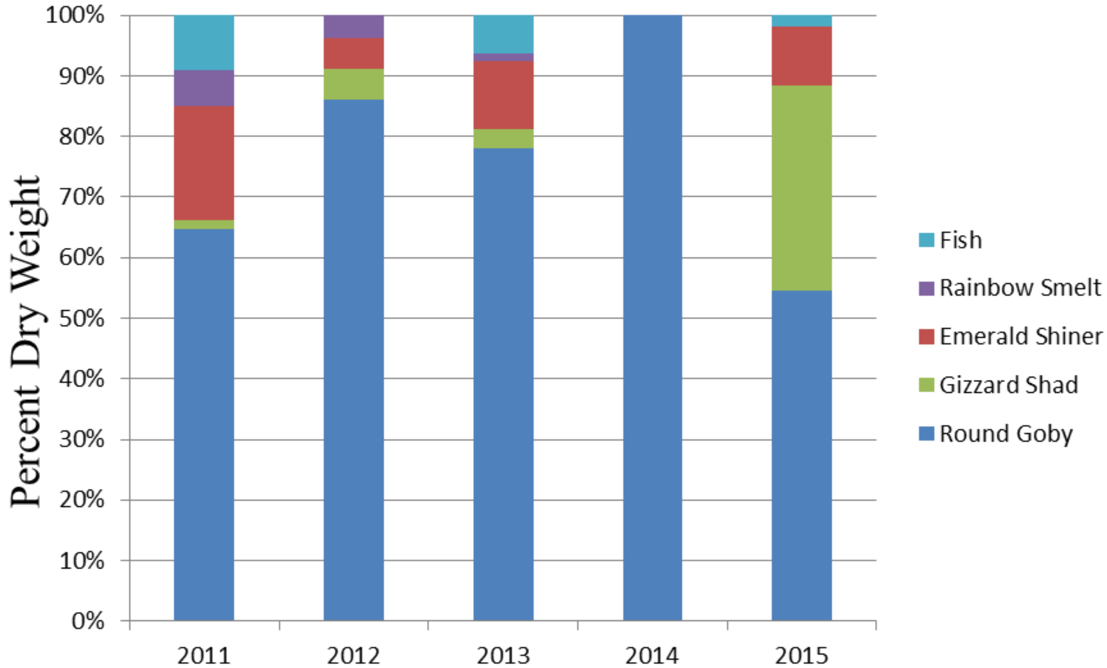

Figure 4.2.2. Adult Smallmouth Bass diet composition (Percent dry weight) from non-empty stomachs collected in gill nets from central basin, Ohio waters of Lake Erie, 2011 - 2015.

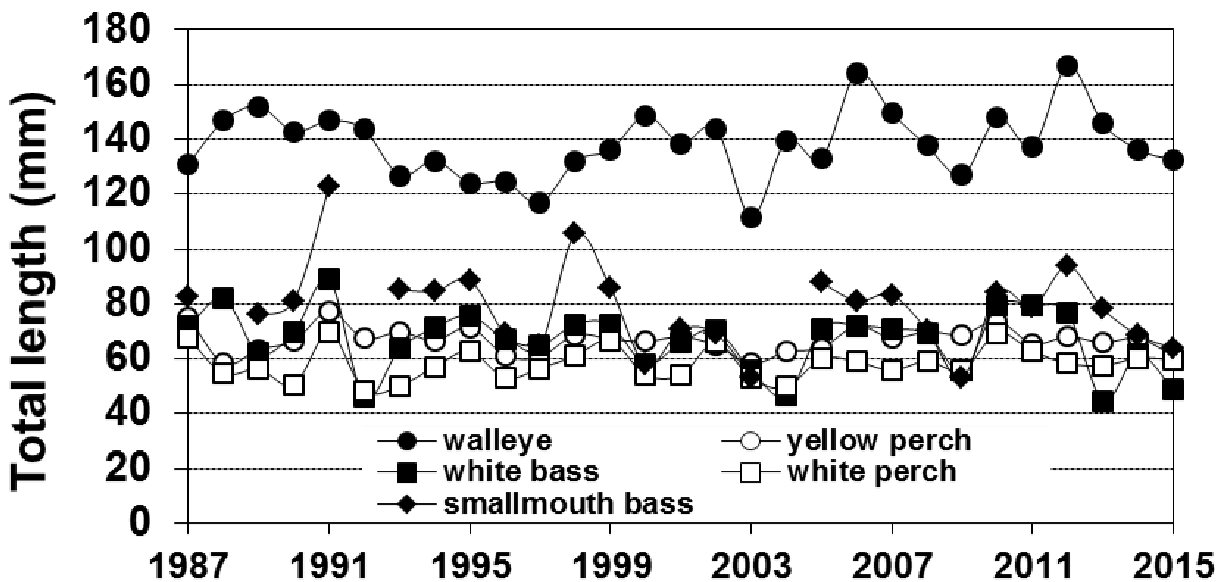

Figure 4.3.1. Mean total length (mm) of select age-0 fishes in western Lake Erie, August 1987- 2015.

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 new Forage Task Group (FTG) 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, Grass Carp and Hemimysis shrimp, was the impetus for creating this new charge. Placing this charge with the Forage Task Group takes advantage of the FTG's access to sampling data throughout Lake Erie, through which many new invasive species are frequently detected (e.g., Round Goby, White Perch).

The primary products of this new charge will be: 1) creation of a list of species of interest that are having or may have a deleterious effect on fisheries; and 2) creation of a Lake Erie non-native aquatic species database, in which abundance and distribution of more recent, non-native species will be tracked. Established non-native species, such as Sea Lamprey, White Perch, and Round Goby are excluded from this charge. More recent invaders, such as *Hemimysis* and Grass Carp are examples of species that will be included.

During the past year, the FTG members have identified invasive species experts currently working in Lake Erie. Their expertise in early detection and monitoring has facilitated the drafting of a short list of priority species for inclusion in the tracking database. To further assist in FTG work on this charge and to ensure inclusivity that is characteristic of management within Lake Erie, the existing members of the Forage Task Group have endorsed the applications of invasive experts and practitioners from Fisheries and Oceans Canada/Pêches et Océans Canada and the US Fish and Wildlife Service for membership on the Forage Task Group. Work on creating the database will take place in 2016. In addition, the Forage Task Group updated the LEC Asian Carp Fact Sheet for 2015.

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. 2016. Report of the Lake Erie Forage Task Group, March 2016. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission, Ann Arbor, Michigan, USA.

Acknowledgments

The Forage Task Group would like to thank Dr. Lars Rudstam (Cornell University), and Dr. Dave Warner (USGS-GLSC) for their continued support of hydroacoustic surveys, section 4.0; and Jason Robinson (NYSDEC), Ben Leonhardt (Ohio State University), Andy Cook (OMNRF), Betsy Bodamer-Scarbro, Bill Edwards, Taylor Stewart (USGS-LEBS) for contributions to multiple sections of this report.

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