Report of the Lake Erie Forage Task Group

March 2001

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Presented to:

Standing Technical Committee
Lake Erie Committee
Great Lakes Fishery Commission

1.0 Charges to the Forage Task Group in 2000-2001

The Forage Task Group (FTG) addressed five major charges from the Lake Erie Committee (LEC) during the 2000-2001work year:

1) Continue to describe the status and trends of forage fish species and invertebrates in 2000 for each basin of Lake Erie (section **2.0**).

2) Continue the investigation and analyses regarding the utility of the interagency trawl assessment program (section **3.0**).

    a) Support the use of SCANMAR equipment for interagency calibration of assessment trawl gear. Continue the development of an experimental design to facilitate forage assessment (section **3.1**).

    b) Complete statistical evaluation of species CPE indices and effects upon sampling from physical and environmental features (section **3.2**).

    c) Trawl Comparison Workshop, information on trawl calibration techniques and analysis. (section **3.3**).

3) Complete bioenergetics simulation to estimate consumption of smelt and other prey fish by predators in Lake Erie (section **4.0**).

4) Continue and expand the fisheries acoustics program to assess pelagic forage fish stocks in Lake Erie (section **5.0**).

    a) Analysis of the eastern basin interagency hydroacoustic survey (section **5.1**).

    b) Continue pilot survey investigations using Lake Erie acoustic system in the central basin of Lake Erie (section **5.2**).

5) Develop and implement an interagency lower-trophic level monitoring program that produces annual indices of trophic conditions that can be included with the Forage Task Group's annual description of forage status (section **6.0**).

The bracketed numbers printed above in bold face, indicate the subsection where progress on a particular charge is reported in this document.

2.0 Forage Task Group Bullet Statements

Eastern basin (by L. Witzel, D. Einhouse, and C. Murray)

- Rainbow smelt, typically the most abundant forage species found in the offshore waters of eastern Lake Erie, was poorly represented in agency fall index trawl catches during 2000 (Table 2.1). OMNR, NYSDEC and PFBC trawl survey data indicate that young-of-year (YOY) smelt abundance increased in 2000, but remained well below long-term average abundance. Yearling-and-older (YAO) (predominately age-1) were exceptionally scarce throughout eastern Lake Erie during 2000, continuing a long-term pattern of alternate years of increased and decreased abundance. OMNR trawl indices indicate YAO abundance was the second lowest observed during the survey's 17-year history. An interagency summer hydroacoustic survey (see section 5.0) indicated that YAO smelt abundance in 2000 was about half the size (in number) as the 1999 estimate. Mean length of age-0 smelt increased in 2000 and Age 1 smelt were about the same size as in 1999 (Figure 2.1).

- The range and abundance of round goby continued to increase in eastern Lake Erie during 2000 (Table 2.1). This exotic species was well established in Pennsylvania's waters of eastern Lake Erie in 1998. By 1999, the round goby had become the most abundant species captured in index trawl gear in that part of the lake (PFBC) and was encountered for the first time in OMNR and NYSDEC index trawl surveys. During 2000 surveys, gobies were encountered at all locations where index trawling was conducted and in densities that represented a several fold increase from the previous year.

- Spottail and emerald shiners (all age groups) exhibited below average abundance in eastern Lake Erie during 2000.

- New York's YOY alewife index in 2000 was the second highest observed during nine years of survey data. Elsewhere in the east basin, the 2000 year class of alewife appeared to be much weaker. All agency surveys indicate poor recruitment of YOY gizzard shad during 2000.

- Trout-perch ranked second in abundance, after smelt, in NYSDEC trawl catches during 2000, but exhibited low abundance elsewhere in the east basin.

- Rainbow smelt continued as the most prominent component of the diet of walleyes sampled from New York's summer sport fishery. Round gobies were commonly observed in the diet of nearshore predators, particularly smallmouth bass (NYSDEC data).

- Age-1 walleyes, age-2 and age-3 smallmouth bass sampled during 2000 index netting surveys were among the largest observed in a 20-year time series.

Central Basin (by J. Deller, T. Johnson, and C. Murray)

- In Ohio waters, overall forage abundance was down from the previous two years, while Pennsylvania forage indices were similar to 1999 (Table 2.2; 2.3). Young-of-the-year fish comprised the majority of the forage base in both Ohio and Pennsylvania in 2000. Young-of-the-year smelt increased from 1999 in both states, however, there has been a general decreasing trend in smelt abundance since 1996. In Ohio, smelt, shiners and white perch had the highest abundance per hectare. There were large increases in clupeid and white perch indices relative to previous years. In 2000, the forage base in Ohio was dominated by pelagic species (emerald shiners, smelt, gizzard shad and alewife). In Pennsylvania, the forage base was dominated by benthic species (round goby). Young-of-the-year walleye and yellow perch declined in all areas of the central basin relative to 1999.

- Young-of-the-year round goby indices decreased from 1999 in both Ohio and Pennsylvania, while YAO round goby indices decreased in Ohio and increased in Pennsylvania relative to 1999. In the Ohio waters of the central basin, both YOY and YAO goby indices have been decreasing since 1998.

- Walleye diets in the fall have been primarily smelt, shiners, gizzard shad and round goby since 1997 (Figure 2.3). Walleye diet samples taken from Ontario partnership gillnets were similar with diets consisting of a mix of smelt, clupeids and shiners. Round goby were present, but were rarely a dominant diet item in Ontario samples. Yellow perch diets from the Ohio waters of the central basin were primarily *Bythotrephes cederstroemi* and round goby. White perch diets were mostly *B. cederstroemi*, *Daphnia* spp. and chironomids. Round goby were significant diet items in walleye, smallmouth, yellow perch, white bass, catfish and burbot diets (Figure 2.4).

- No trends in annual growth are evident for age-0 forage species in the central basin during the 1990's. However, since 1998 YOY yellow perch mean size has ranged from 85 to 89 mm. These are some of the largest sizes attained by YOY yellow perch in the 1990's.

- Lower trophic level sampling was conducted at four sites in the central basin. Two sites each are located off Wheatley, Ontario and Fairport Harbor, Ohio. Across the basin, total phosphorous and chlorophyll a levels increased from 1999, especially at the nearshore sites. Benthic samples from Ontario sites consisted of oligochaetes, chironomids and nematodes. There were no amphipods, bivalves or gastropods present in the samples. At this time, remaining zooplankton samples are being processed and data will be included in future reports as analyses are completed.

Western Basin (by T. Johnson, J. Tyson and M. Thomas)

- Overall, forage fish density was higher in 2000 (Figures 2.4; 2.5), driven primarily by alewife, age-0 gizzard shad and age-0 smelt. Little change was seen in biomass because of the poor growth of most species. Total forage abundance and biomass remains below the long-term average because of continued low white perch abundance. Both yellow perch and walleye produced poor year-classes in 2000.

- Mean length of age-0 walleye was above average in 2000, although this may be a function of their very low density. Length of age-0 perch declined in 2000 and remained below the long-term average.

- Round goby abundance remained the same or decreased slightly in 2000 (Figure 2.6). Intense predation on gobies by numerous fish species may limit their survival and abundance in the west basin.

- Round gobies were evident in the diets of all piscivorous fishes examined in 2000, although their importance varied with species. Walleye diets remained dominated by alewife and gizzard shad, while yellow perch diets contained high fractions of *Hexagenia* (Figure 2.7). Demersal fish (catfish, smallmouth bass) showed a stronger dependency on round gobies than pelagic species (walleye and white bass).

- Total phosphorus concentration was higher at most stations in 2000, especially the nearshore Ohio station where above average precipitation may have produced increased runoff. Chlorophyll *a* concentrations were slightly lower, a possible response to cooler temperatures and a poor light environment in 2000. Many parameters were more variable in 2000 than in 1999, a possible consequence of higher winds and precipitation. Preliminary zooplankton densities were similar to 1999, although zebra mussel veligers declined at offshore locations. Benthic samples were dominated by oligochaetes, chironomids and nematodes.

Lake St. Clair (by M. Thomas)

- Clupeid densities in 2000 were consistent with the previous three years. Alewife accounted for 77% of the clupeid abundance. Gizzard shad YOY in Lake St. Clair are restricted to the southeast area of the lake, near the mouth of the Thames River.

- Soft-rayed forage density remained much lower than that observed in 1996 and 1997, but about the same as in 1999. Mimic shiners accounted for 58% of the total soft-rayed abundance. Spottail shiner and trout-perch are the other primary components of the soft-rayed functional group.

- Round goby densities remained about the same in 2000, at a density of 100 fish per hectare, and tend to be highest in nearshore areas.

- Mean length of round gobies collected from Lake St. Clair in Sept. 2000 was 83mm. Round gobies exceeding 120 mm are uncommon in Lake St. Clair. This truncated length distribution may be the result of heavy predation pressure in Lake St. Clair, where predator densities are high. Round gobies have been observed in the diet of yellow perch, walleye, smallmouth bass, channel catfish, and mudpuppies from Lake St. Clair.

3.0 Interagency Trawling Program

An ad-hoc Interagency Index Trawl Group (ITG) was formed in 1992 to first view the interagency index trawl program in western Lake Erie and recommend standardized trawling methods for assessing fish community indices; and second, to lead the agencies in calibration of index trawling gear using SCANMAR acoustical instrumentation. Before dissolving in March 1993, the ITG recommended the Forage Task Group (FTG) continue the work on interagency trawling issues. Progress on these charges is reported below.

3.1 Trawl Calibration (M. Bur)

Use of the SCANMAR acoustical equipment has assisted the Lake Erie management agencies in standardizing their prey fish reporting format (#/ha) by evaluating the actual fishing dimensions of all agency trawl gear. The Great Lakes Science Center (USGS-BRD) has made the SCANMAR equipment available to the Lake Erie agencies at no cost. In 2000, the USGS had the entire system re-calibrated and invested additional monies in storage containers to ensure the equipment is not damaged during transport around the Great Lakes. In 2001, Ohio is planning to use the SCANMAR equipment to measure trawl configuration aboard the new RV Explorer. If demand for this gear increases, it may be more advantageous for the Lake Erie agencies to purchase similar equipment in the future.

3.2 Summary of Species CPUE Statistics

(by T. Johnson, J. Tyson, and M. Thomas)

Interagency trawling has been conducted in Ontario, Ohio and Michigan waters of the western basin of Lake Erie in August of each year since 1987. This interagency trawling program was developed to measure basin-wide recruitment of percids. More recently, the interpretation has been expanded to provide basin-wide community abundance indices, including forage fish abundance and growth. Information collected during the surveys includes length and abundance data on all species collected. A total of 62-90 standardized tows conforming to a depth-stratified (0-6m and >6m) random design are conducted annually by OMNR and ODNR throughout the western basin; results of 62 trawls were used in the analyses in 2000 (Figure 3.1).

In 1992, the ITG recommended that the FTG review it's 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 between agencies. In 1992, in response to the ITG recommendation, the FTG began the standardization and calibration of trawling procedures between 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.

The FTG recognizes the increasing interest in using information from this bottom trawling program to express abundance and distribution of the entire prey fish community of the western basin. Preliminary survey work by OMNR in 1999 demonstrated the potential to underestimate the abundance of pelagic fishes (principally clupeids and cyprinids) when relying solely on bottom trawls. Therefore, as part of the joint trawling exercises described in the *Trawl Comparison Workshop* section, OMNR and ODNR plan to incorporate mid-water trawls and hydroacoustics to estimate the abundance of all available fish species. These exercises are not intended to replace the bottom trawling program but rather estimate the biases in our current approach and explore alternative techniques that may supplement our current long-term program. To this end, the FTG will continue to explore the use of hydroacoustic techniques in the central and western basin of Lake Erie, recognizing the strength of this tool for pelagic fish assessment. However, the shallow depths and complex bathymetry of the western basin provide challenges to implementing a hydroacoustic program in this basin, such that other pelagic sampling techniques may be explored. Both OMNR and ODNR are committed to completing the needed standardization and comparison exercises outlined above and in the *Trawl Comparison Workshop* section.

Presently, the FTG estimates basin-wide abundance of forage fish in the western basin using information from SCANMAR trials, total trawling distance, and catches from the August interagency trawling. Species-specific abundance estimates (#/ha or #/m^3) are combined with length-weight data to generate a species-specific biomass estimate for each tow. Volumetric estimates of abundance and biomass are extrapolated by depth strata (0-6m, >6m) to the entire western basin to obtain an absolute estimate of forage fish abundance and biomass for each species. For reporting purposes, species have been pooled into three functional groups: clupeids (age-0 gizzard shad and alewife), soft-rayed fish (rainbow smelt, emerald 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). However, basin-wide absolute estimates must be viewed with respect to gear biases stated above.

Total forage abundance and biomass increased in the western basin in 2000, relative to 1999. Clupeids were the dominant prey group collected in 2000 bottom trawls, followed by spiny-rayed then soft-rayed fishes (Figure 3.2 to 3.4). The large increase in clupeid abundance in Ohio relative to Ontario is most likely an artifact of extrapolation. Ohio samples are more evenly distributed between depth strata, whereas Ontario did not sample any stations in the 0-6m strata in 2000 owing to low water levels. Smaller size of many spiny-rayed fishes led to a net reduction in their biomass, while changes in the other functional groups were in proportion to changes in abundance (Figure 3.5 to 3.7). Walleye and yellow perch year-classes were well below average, while gizzard shad and white perch both experienced large increases in age-0 production.

Spatial maps of forage distribution were constructed using site-specific catches (#/ha) of the functional groups. Abundance contours were generated using inverse distance to power contouring techniques to interpolate abundance between trawl locations. Abundance of clupeids was highest in the north central portion of the basin, a pattern seen in previous years (Figure 3.8a). Very high abundance of gizzard shad occurred offshore from Cedar Creek, Ontario. Soft-rayed fish (predominantly age-0 rainbow smelt) were most abundant off Sandusky Bay, and in the northwest portion of the basin (predominantly trout-perch) (Figure 3.8b). This pattern was quite different from that seen in 1999 when abundance was highest in the southwest region of the basin. Spiny-rayed abundance was dominated by age-0 white perch. Peak abundance was seen in the southeast and central portions of the basin (Figure 3.8c), a pattern similar to that seen in previous years. Total forage abundance averaged 4,000 fish/ha across the western basin, an increase from 1,500 fish/ha in 1999.

3.3 Trawl Comparison Workshop (by J. Tyson, T. Johnson and M. Thomas)

One of the strengths of the interagency reporting format is that the distribution and abundance of fishes can be represented across the entire basin, irrespective of jurisdictional boundaries that have no influence on fish behavior. However, differences in trawl design, vessel operation, sample processing and interpretation of data can confound the pooling of the data. The SCANMAR exercise has provided a means to calibrate each agency trawl to it's true fishing configuration (height and width of mouth opening); but does not address other potential differences between agency trawling programs. Therefore, in August 2000, the Forage Task Group, in conjunction with the Ohio Chapter of the American Fisheries Society, conducted a workshop to address trawl calibration techniques and analyses. Paul Von Szalay, an expert in trawl calibration from NOAA's Alaska Fisheries Science Center presented a two-day workshop entitled *Correcting for Fishing Power Differences Between Vessels.*

Initially, Paul addressed reasons for correcting for fishing power differences. The first reason for addressing correction factors was to remove bias in the catch-per-unit-effort data. Additionally, fishing power correction factors (FPCs) allow for comparison and integration of data sets collected by different vessels or through time periods where survey vessels or gear configurations change. Fishing power correction factors also allow for the generation of absolute abundance estimates among agencies. Paul then listed several options or strategies available to agencies in this situation and presented cost/benefits associated with each strategy.

Paul next discussed a method for determining whether to apply an FPC. He outlined a method using the mean squared error (MSE) of the mean catch-per-unit-effort as a decision rule. This decision rule was first proposed by Peter Munro (1998). One of the big tradeoffs inherent in applying a FPC is that you add variance to reduce the bias in the estimates. After application of a FPC you have two components of variance: sampling variance in observations, and variance due to uncertainty in the estimate of FPC. The decision rule for application of a FPC states that you apply the FPC only if the $MSE[CPUE_{uncorrected}]>MSE[CPUE_{corrected}]$. Paul then discussed how to generate the MSE decision curve (see Figure 3.9).

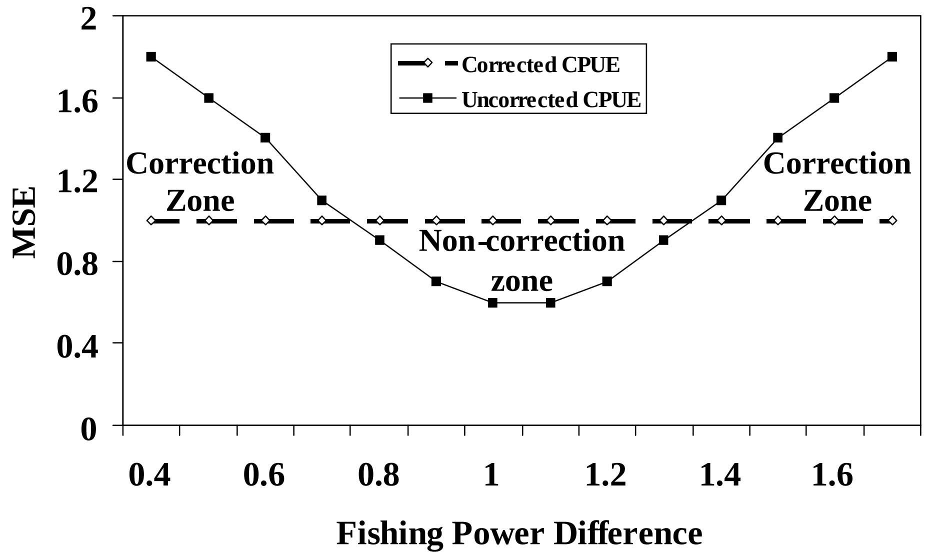


Figure 3.9 Decision curve for application of FPC. Plot is MSE of mean catch per unit effort against fishing power differences

Several methods for estimating Fishing Power Correction factors were discussed including the ratio of mean CPUEs, the Kappenman estimator, the mean of the CPUE ratios, and the multiplicative model. All of these estimators had advantages and disadvantages to their use.

The final part of the workshop was devoted to outlining a program for conducting fishing power correction experiments. The procedure involves:

1) Select a standard vessel to compare all others to
2) Standardize methodology (trawl configuration, vessel speed, physical environment, etc.) as much as possible
3) Randomize the relative position of the other vessels relative to the standard vessel
4) Begin trawling with the objective of collecting as many hauls as possible (typically >30) during the pilot study.
5) Generate the MSE decision curves for each species of interest based on the pilot data
   a) Calculate "true" mean CPUE for the standard vessel and the associated standard deviation
   b) Fit the CPUE data to an appropriate probability distribution function (i.e. derive the parameters of the function)
   c) Impose different fishing power differences on the pilot data
6) Calculate the estimated fishing power correction from the pilot data using the estimator of choice
7) See where the estimated FPC value is relative to the non-correction zone
   a) If FPC is within the non-correction zone, don't apply an FPC
   b) If FPC is outside of the non-correction zone, is it feasible to apply the FPC?
8) Run a power analysis to estimate the required sample size to detect a difference in fishing power – i.e. required number of hauls for the FPC experiment
9) Run formal FPC experiment – apply FPC to the non-standard vessels

Due to logistic constraints, the comparative trawling experiment was not completed in 2000 as scheduled. Therefore, comparative trawling has been tentatively rescheduled for the summer of 2001.

Literature Cited

Munro, P.T. 1998. A decision rule based on the mean square error for correcting relative fishing power differences in trawl survey data. Fisheries Bulletin 96: 538-546.

4.0 Bioenergetics Modeling of Predator Consumption

(by L. Witzel, T. Johnson, A. Cook and D. Einhouse)

In March 1996, the Lake Erie Forage Task Group was charged with measuring consumption of smelt and other prey fish by the major predators in Lake Erie. We expect to complete this charge during the year 2001-2002 work period using revised estimates of walleye abundance that resulted from a recent review of walleye population estimation techniques.

5.0 Acoustic Survey Program

(by D. Einhouse, L. Witzel, C. Murray and L. Rudstam)

Introduction

Since 1993, the Forage Task Group has used a fisheries acoustic system as an additional tool to assess forage fish stocks in eastern Lake Erie. These fisheries acoustic surveys have been conducted annually from 1993 to 2000. The 1993 to 1996 surveys were principally summertime efforts using the New York State Department of Environmental Conservation's 70-kHz single beam echosounder (Simrad EY-M, 7024 transducer). Since 1996, acoustic survey efforts have used a modern 120-kHz split-beam system (Simrad EY-500) that was jointly purchased by the Lake Erie Committee member agencies and the Great Lakes Fishery Commission. The 1998 and 1999 survey used this split-beam system for the ongoing July survey, as well as, basin wide surveys in spring (June) and fall (October) in the eastern basin. In 2000, only the long term July acoustic survey was continued to monitor pelagic forage fish density and distribution in eastern Lake Erie. Only the ongoing July acoustic survey results are presented in this report as the long-term abundance index for eastern basin pelagic forage fish that has been underway since 1993. The 2000 data collection was coordinated among three agencies (NY, ONT, and PA), with three research vessels (Argo, Erie Explorer, and Perca) participating in various aspects of the data collection and calibration.

5.1 Eastern Basin Acoustic Survey

(by D. Einhouse, L. Witzel, C. Murray and L. Rudstam)

Methods

The 120 kHz split beam echo sounder was calibrated at the beginning of the July 2000 eastern basin survey. Acoustic signals were processed/analyzed using the EY500/EP500 analysis software (version 5.3, Simrad 1996). This software calculates total volume back scattering strength and single fish target strength (TS) simultaneously by applying 20 and 40 log R TVG functions. Fish densities within -3 dB TS bins were calculated by apportioning the volume back scattering strength to the proportion of single fish echos within each target strength bin. The lower threshold for volume back scattering and the single fish target strength threshold was set to -64 dB. From these split beam data, we selected a subset TS range of -55 dB to -43 dB as an index of (YAO) pelagic forage fish (~ > 50 mm). We believe this acoustic size range is also comparable to a length range for adult-sized forage fish, fully vulnerable to agency trawling programs during summer. We used a -56 dB to -44 dB TS range from the earlier (1994-96) single beam surveys for contrasting pelagic forage fish abundance across a 6-year time series. Rudstam et al. (1999) found the Simrad EY-M single beam system used prior to 1997 produced similar, but not identical results, in describing target strength and fish density relative to the modern split beam acoustic systems. Although Rudstam et al. (1999) suggested single beam density estimates are 85 to 95% lower than those produced from split beam systems, we have not yet applied any scaling factor for comparing 1993-96 single beam and 1997-2000 split beam results.

Data acquisition throughout the July 2000 effort occurred at night with vessel speeds between 5.0 and 6.0 knots with a transducer affixed to the hull of the acoustic survey vessel (*RV Erie Explorer*). Acoustic data were stratified vertically by thermal layer (epilimnion, thermocline, hypolimnion), and horizontally by the area encompassed within three depth contours (15 -25 m, 25 -35 m, and >35 m). In the early years of this survey, thermal strata were identified by a temperature profile sampled approximately in the middle of each transect. However, over time it became apparent that a characteristic dense band of fish accompanied by TS distributions changing from predominately smaller to larger targets was a reliable indicator of the thermocline layer. Therefore, in surveys since 1997 we used these indirect thermocline indicators as the primary criteria for defining thermal strata. In 2000, the water column examined within these eastern basin strata began from 3.0-m below the surface to exclude surface noise, to a backstep of 1-m above the detected bottom.

A mid-water trawl survey was conducted concurrent to the acoustic sampling in eastern Lake Erie. In 2000, the trawling was conducted aboard the *RV Argo* using a mid-water trawl with fishing dimensions of 36 m^2. The 2000 mid-water trawl survey was expanded spatially and in number of sites sampled relative to past mid-water trawl surveys. The mid-water trawling effort in ensuing years is expected to remain similar to the expanded effort in 2000. All trawl samples were counted by species and sub-samples of each collection were measured for total length.

Results and Discussion

The July 2000 acoustic survey suggested a pattern of YAO pelagic fish abundance similar to previous efforts. The pattern from previous years' collections reliably found pelagic fish densities concentrated near the thermocline, particularly in locations where the thermocline was in close proximity to the bottom. The lowest YAO pelagic fish densities most often occurred centrally over the deepest portion of the eastern basin in surveys. This characteristic pattern of pelagic fish abundance continued during the 2000 survey (Figure 5.1.1).

Accompanying nighttime, mid-water trawl samples have been collected annually during this acoustic survey. For most of this time series, the companion trawling effort has been very limited for each individual survey. However, the 2000 survey was accompanied by expanded trawl collections and corroborated the earlier limited efforts since 1993. Mid-water trawl collections consistently describe the species composition of this pelagic fish community as dominated by rainbow smelt (Table 5.1.1). During 2000, the collections made in the metalimnion and hypolimnion contained over 99 % rainbow smelt.

The trawling and acoustic efforts together describe this smelt resource as consisting of two abundant groups (age-0 and age-1+) that vertically separate in the water column due to differing thermal preferences during summer stratification. As such, we ascribe thermocline and hypolimnion densities within the -55 to -43 dB range as our approximation of YAO smelt abundance. This definition of YAO rainbow smelt suggests 2000 abundance was considerably lower than 1999. Furthermore, a characteristic alternate year high and low abundance pattern since 1995 is apparent in YAO rainbow smelt abundance through our brief time series (Figure 5.1.2). During the 2000 acoustic survey, the majority of eastern basin rainbow smelt were found in the stratum between 35 and 65 m (Table 5.1.2).

A more thorough examination of smelt abundance and distribution from 8 years of acoustic survey work is planned to quantify absolute biomass and production in eastern Lake Erie. This effort will include supplemental data collected in 1998 and 1999 that is not included in this report. Expanded acoustic survey efforts in 1998 and 1999 provided an opportunity to conduct fixed station acoustic sampling and more closely examine target strength patterns of smelt cohorts. The supplemental surveys were also distributed throughout the field season providing spring, summer and fall snapshots of changes in biomass and distribution. This information is expected to be particularly useful for understanding predator demand over the time series (see Bioenergetics Charge). In 2001 and 2002, the Forage Task Group is anticipating continued support from research efforts directed at understanding acoustic target strength patterns of rainbow smelt.

5.2 Central Basin Acoustic Survey (by L. Witzel and T. Johnson)

An acoustic survey of Lake Erie's central basin was conducted by OMNR during September 2000. Three across basin transects totaling 244 km in distance were planned, but foul weather restricted the survey to a single night's effort. Approximately 75 km of acoustic data without concurrent mid-water trawl data were collected along a transect running from Erieau, Ontario to the East Side of Cleveland, Ohio. The water column at the time of the survey (September 18-19) was largely isothermal at 19 C. Results of the 2000 weather-reduced survey were not available for this report. An acoustic survey of Central Lake Erie is planned for the year 2001.

Acknowledgments

The FTG is grateful to OMNR research vessel captain Gordon Ives, OMNR biologist Becky Sherman, PFBC research vessel captain Paul Atkinson, and NYS DEC staff, Douglas Zeller (research vessel captain), Richard Zimar, and Brian Beckwith (fish and wildlife technicians) for their annual contributions in support of the eastern basin acoustic survey.

Literature Cited

Rudstam, L.G., S. Hansson, T. Lindem, and D.W. Einhouse. 1999. Comparison of target strength distributions and fish densities obtained with split and single beam echo sounders. Fisheries Research 42:207-214.

6.0 Interagency Lower Trophic Level Monitoring Program

(by B. Trometer and T. Johnson)

Introduction and Methods

In 1999, the FTG agencies initiated the first year of the Lower Trophic Level Assessment program (LTLA) within Lake Erie and Lake St. Clair (Figure 6.1). Nine key variables, identified by a panel of experts, were measured to characterize the state of the ecosystem. These variables included profiles of temperature, dissolved oxygen and light (PAR), water transparency (Secchi), 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. In 1999, collections were made at 18 of the 20 stations from 2 to 14 times. In 2000, collections were made at all 20 stations from 3 to 14 times. Sampling generally occurred on the beginning of the first week of the sampling period, but sometimes occurred in the second week.

Results for 2000

Water temperature profiles indicate that western basin was isothermal all year. Offshore stations in the central basin were stratified from approximately June 26 through September 18. Deep stations in the eastern basin were stratified from approximately June 20 through end of September. At each station bottom dissolved oxygen (DO) was highest in May, declined through the summer, and started to recover in September after fall turnover (Figure 6.2). Bottom DO was very low in the central basin, especially at station 10 where measurements under 5 mg/L were recorded for 4 out of 9 dates.

A gradient in water transparency existed from west to east (Figure 6.3). Secchi depths were shallowest in the western basin, ranging from 0.2 and 4.0 meters, increased to 0.5 and 9.1 m in the central basin, and 1.8 and 11.8 m in the eastern basin. Lake St. Clair Secchi depths were similar to western basin Secchi depths ranging from 0.6 to 4.3 m. Light extinction was only measured at 2 stations in the western basin and 2 stations in the central basin. The light extinction coefficient was generally higher in the western basin and peaked during fall mixing. In the central basin, the light extinction coefficient remained relatively constant throughout the sampling period.

A west to east gradient also existed for total phosphorus and chlorophyll *a* concentrations (Figures 6.4; 6.5). Concentrations of both total phosphorus and chlorophyll *a* were generally lowest in the eastern basin and highest in the western basin. Chlorophyll *a* concentrations were more variable in the western and central basins than in the eastern basin. Phytoplankton samples were collected and archived for all stations.

Zooplankton and benthic samples were collected, but have not been processed at this time. Information on those samples will be presented in this report when all the data is available.

7.0 Lakewide Round Goby Distribution (by B. Haas and J. Tyson)

Round goby (*Neogobius melanostomus*), first discovered in St. Clair River in 1990, became established in the central basin of Lake Erie in 1994. Because of the prolific nature of this exotic species, as well as the potential trophic and competitive impacts of the round goby, the Forage Task Group constructed distribution maps of round gobies based upon agency bottom trawling data (Figure 7.1). Round goby abundance data (#/hectare) were obtained from OMNR, ODNR, PFBC, and NYSDEC bottom trawl surveys conducted from August-October of each year. A total of 1902 trawls were included in the analysis, with 186-375 sites being sampled per year across the lake. A large area in the northern half of the central basin was not sampled with bottom trawls, therefore this area was blanked out. Grid contours of goby density were generated using kriging techniques with a 300 X 300 grid density.

Round gobies were first observed at relatively low densities in the central basin of Lake Erie in 1994. However, within two years, the round goby population had increased by two orders of magnitude. Concurrent with the increases in abundance, there was also an east and westward expansion, such that the majority of the central basin had established populations of round gobies by 1996. By 1997 and 1998, round gobies were becoming well established in the western basin and western portions of the eastern basin. By 1999, with the expansion of the round goby into Long Point Bay and New York waters, all agency bottom trawl surveys had recorded round gobies.

In 1999, round goby abundance appeared to be higher in the central basin relative to other areas of Lake Erie. Round gobies comprised 10% and 95% of the total catch in Ohio and Pennsylvania bottom trawls in the central basin, respectively. Densities of round gobies ranged from 0-8000 gobies per hectare. However, bottom trawls most likely underestimate true round goby abundance because of the gobies' preference for rocky habitat that is difficult to sample. The peak abundance of round gobies in the western basin in 1999 demonstrates this. This peak was generated from a single trawl that was torn, while trawling on rocky substrate. Therefore, these site-specific density estimates should be treated as minimum estimates. Basin-wide goby abundance, however, is likely higher in the central basin due to the much higher percentage of rocky substrate in the central basin, relative to the western basin. Eastern basin abundance estimates may rival those of the central basin in the future, due to an abundance of rocky substrate and *Driessena.*

In 2000, round goby are well established in all areas of the lake that are currently being sampled. Goby populations continued to increase their range and abundance in the eastern basin of Lake Erie. In areas other than the eastern basin, goby abundances have remained the same or decreased relative to 1999. Declines are particularly noticeable in the central basin where they were originally established in 1994. In these areas, goby abundances have declined from a peak of 429/ha in 1998 to 162/ha in 2000. These declines may be due in part to increased predation by piscivores.

Initially, predators in Lakes Erie and St. Clair appeared not to utilize round goby, but now feed on them extensively in all basins, especially the west and central basins. Gobies are now common in the stomachs of yellow perch, smallmouth bass, white bass, freshwater drum, catfish and walleye. It is our opinion that round goby will continue to provide an energy and possibly a contaminant link between zebra mussels and top predators.

8.0 Protocol For Use of FTG 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 received from the agency responsible for the data collection.

Table 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 in 2000 and 1999. Indices are reported as arithmetic mean number caught per hectare (NPH) for the age groups young-of-year (YOY) and yearling-and-older (YAO). Long-term averages are reported as the mean of the annual trawl indices for survey years during the present (90's Avg.) and previous (80's Avg.) decades. Agency trawl surveys are described below.

	Trawl	**YOY**				**YAO**			
Species	**Survey**	**2000**	**1999**	**90's Avg.**	**80's Avg.**	**2000**	**1999**	**90's Avg.**	**80's Avg.**
Smelt	ON-DW	254.7	27.8	476.3	1372.8	29.7	138.4	405.9	961.9
	NY-Fa	1184.7	895.5	1450.9	NA	74.4	805.2	581.6	NA
	PA-Fa	136.1	35.6	550.8	7058.1	0.0	4.9	378.0	2408.6
Emerald Shiner	ON-DW	3.2	17.1	54.1	20.3	691.4	4.8	45.9	37.8
	ON-OB	19.9	1.5	113.1	152.5	19.9	0.0	47.7	133.5
	NY-Fa	43.6	10.8	112.4	NA	42.6	15.7	105.4	NA
	Pa-Fa	0.0	1.4	41.0	118.3	0.0	0.0	14.5	45.6
Spottail Shiner	ON-OB	1137.4	589.4	697.2	245.6	45.2	88.4	52.6	21.6
	ON-IB	2.3	67.0	113.5	293.4	0.4	1.9	2.0	9.5
	NY-Fa	0.1	1.0	19.9	NA	0.1	1.0	4.0	NA
	PA-Fa	0.0	0.3	4.0	2.0	0.0	0.0	7.9	12.4
Alewife	ON-DW	24.4	1079.1	124.6	21.3	NA	NA	NA	NA
	ON-OB	16.8	0.2	61.0	51.5	NA	NA	NA	NA
	NY-Fa	214.5	0.3	52.0	NA	NA	NA	NA	NA
	PA-Fa	0.0	0.0	7.7	16.6	NA	NA	NA	NA
Gizzard Shad	ON-DW	0.3	41.6	5.1	15.2	NA	NA	NA	NA
	ON-OB	6.0	5.0	9.6	24.3	NA	NA	NA	NA
	NY-Fa	0.1	6.8	4.2	NA	NA	NA	NA	NA
	PA-Fa	0.0	0.0	0.9	74.3	NA	NA	NA	NA
White Perch	ON-DW	0.0	0.5	2.1	5.6	NA	NA	NA	NA
	ON-OB	6.1	0.3	14.1	28.7	NA	NA	NA	NA
	NY-Fa	0.7	0.8	29.4	NA	NA	NA	NA	NA
	PA-Fa	7.8	2.4	101.1	955.0	NA	NA	NA	NA
Round Goby[a]	ON-DW	49.8	0.2	0.0	0.0	NA	NA	NA	NA
	ON-OB	24.1	0.5	0.1	0.0	NA	NA	NA	NA
	NY-Fa	282.3	8.1	1.0	NA	NA	NA	NA	NA
	PA-Fa	1350.6	171.7	30.3	0.0	NA	NA	NA	NA

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

[a] Trawl indices for round goby reported as "all ages" under the heading for YOY.

Ontario Ministry of Natural Resources

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 GMCPTH: 80s Avg. is for period from 1984-1989; 90s Avg. is for period from 1990-1999.

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 GMCPTH; 80s Avg. is for period from 1984-1989; 90s Avg. is for period from 1990-1998

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 GMCPTH; 80s Avg. is for period from 1984-1989; 90s Avg. is for period from 1990-1999.

New York State Department of Environmental Conservation Trawl Survey

NY-Fa: Trawling is conducted at 30 nearshore (15-28 m) stations during October using a 10-m trawl with a 9.5-mm mesh cod end liner. Indices are reported as NPH; 90s Avg. is for the period from 1992-1999.

Pennsylvania Fish and Boat Commission Trawl Survey

PA-Fa: Trawling is conducted at nearshore (<22 m) and offshore (>22 m) stations during October using a 10-m trawl with a 6.4-mm mesh cod end liner. Indices are reported as GMCPTH; 90s Avg. is for period from 1990-1999, excluding 1993 and 1997.

Table 2.2. Relative abundance (arithmetic mean number per hectare) of selected young-of-the-year species from fall trawl surveys in the central basin, Ohio and Pennsylvania, Lake Erie, from 1990-2000.

Species	Agency	Year 1990 [a]	1991 [a]	1992 [a]	1993 [a]	1994 [a]	1995	1996	1997	1998	1999	2000	Mean
Alewife	OH	0.3	5.7	27.5	0.0	7.7	12.8	9.6	14.7	6.3	15.2	34.9	12.2
	PA	0.0	-	174.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.3
Gizzard Shad	OH	29.9	2.6	8.2	2.1	10.7	1.4	103.1	11.6	33.7	48.8	64.4	28.8
	PA	41.0	-	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6
Rainbow Smelt	OH	1004.5	13.1	641.2	19.9	1076.9	740.1	1359.6	431.2	606.2	213.4	579.4	607.8
	PA	1128.0	-	8205.0	-	953	107.0	5422.0	10.0	30.0	2.0	15.0	1763.6
Emerald Shiner	OH	246.0	126.8	105.7	4.8	28.2	20.0	38.9	78.3	2096.5	343.1	291.8	307.2
	PA	366.0	-	34.0	-	0.0	54.0	4.0	0.0	6.0	0.0	0.0	51.6
Spottail Shiner	OH	0.9	0.1	0.4	5.2	7.9	0.8	15.1	7.0	1.4	4.2	0.2	3.9
	PA	0.0	-	0.0	-	0.0	20.0	0.0	0.0	0.0	1.0	0.0	2.3
Trout-Perch	OH	7.1	2.3	20.5	2.8	0.0	5.1	12.3	0.8	0.8	3.7	0.5	5.1
	PA	0.0	-	214.0	-	1.0	25.0	7.0	0.0	23.0	10.0	23.0	33.7
White Perch	OH	1348.4	1026.1	148.3	67.9	197.1	27.4	355.1	128.3	83.3	175.1	227.4	334.0
	PA	1528.0	-	887.0	-	76.0	136.0	332.0	0.0	0.0	8.0	76.0	338.1
White Bass	OH	47.8	12.7	0.5	38.5	147.3	20.5	65.3	15.7	41.7	108.4	20.7	47.1
	PA	17.0	-	0.0	-	7.0	4.0	0.0	0.0	0.0	0.0	96.0	13.8
Yellow Perch	OH	28.0	4.9	28.5	10.8	40.0	5.3	121.8	7.7	69.4	42.4	9.3	33.5
	PA	9.0	-	125.0	-	567.0	52.0	354.0	0.0	14.0	7.0	16.0	127.1
Round Goby	OH	-	-	-	-	2.9	29.0	30.2	86.8	151.1	129.0	78.3	72.4
	PA	-	-	-	-	0	0	0	1	744	1114	781.0	377.1

[a] Fairport values have been scaled to compare with trawl equipment used prior to 1995.

Table 2.3. Relative abundance (arithmetic mean number per hectare) of selected yearling-and-older species from all trawl surveys in the central basin, Ohio and Pennsylvania, Lake Erie, from 1990-2000.

		Year											
Species	**Agency**	**1990 [a]**	**1991 [a]**	**1992 [a]**	**1993 [a]**	**1994 [a]**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**Mean**
Alewife	OH	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.7	0.1
	PA	0.0	-	61.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8
Gizzard	OH	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	2.6	0.3
Shad	PA	1.0	-	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Rainbow	OH	19.5	103.0	39.3	111.2	41.5	141.8	84.2	360.3	85.4	829.6	125.3	176.5
Smelt	PA	43.0	-	541.0	-	4	506.0	30.0	0.0	0.0	0.0	6.0	125.6
Emerald	OH	145.7	155.2	7.3	12.8	9.4	30.0	16.2	104.5	830.3	454.3	440.6	200.6
Shiner	PA	3.0	-	241.0	-	1.0	18.0	0.0	0.0	0.0	0.0	29.0	32.4
Spottail	OH	2.2	0.7	0.8	0.3	6.0	9.3	12.6	10.1	15.1	5.4	7.2	6.3
Shiner	PA	18.0	-	0.0	-	0.0	18.0	0.0	0.0	0.0	0.0	0.0	4.0
Trout-	OH	6.4	6.6	11.3	5.7	6.1	11.7	10.9	15.7	17.2	8.4	12.4	10.2
Perch	PA	64.0	-	133.0	-	7.0	53.0	0.0	0.0	0.0	0.0	12.0	29.9
White	OH	81.2	226.2	133.9	1.4	0.8	23.5	15.1	48.0	3.3	31.4	65.3	57.2
Perch	PA	42.0	-	61.0	-	0.0	2.0	2.0	0.0	0.0	1.0	0.0	12.0
White	OH	0.1	0.0	0.5	0.0	0.0	3.1	0.3	13.8	0.3	3.6	17.6	3.6
Bass	PA	5.0	-	0.0	-	3.0	0.0	0.0	0.0	0.0	1.0	1.0	1.1
Yellow	OH	15.7	30.6	7.9	21.0	6.5	47.6	8.6	117.6	3.4	45.6	38.9	31.2
Perch	PA	51.0	-	58.0	-	2.0	192.0	12.0	0.0	0.0	7.0	3.0	36.1
Round	OH	-	-	-	-	3.0	78.6	133.6	268.8	175.7	98.6	81.0	119.9
Goby	PA	-	-	-	-	0	0	0	0	33	0	124.0	22.4

[a] Fairport values have been scaled to compare with trawl equipment used prior to 1995.

Table 2.4 Estimated abundance (#/hectare) of functional prey fish groups in Lake St. Clair, from Michigan DNR August trawls, 1996-2000.

	1996	**1997**	**1998**	**1999**	**2000**	**Mean**
Clupeids	196.9	29.3	22.4	19.0	22.9	57.8
Soft-rayed (w/o round goby)	1621.2	1520.1	596.3	306.4	314.2	883.3
Spiny-rayed	401.1	159.7	203.9	87.4	58.0	186.1
Round goby	51.1	55.0	83.5	99.0	100.4	77.2

Table 5.1.1 Summary of nighttime, summer mid-water trawl catches of yearling-and-older fishes (> 50 mm) used to characterize species composition for acoustic density estimates of pelagic forage fish in offshore areas (>15 contour) of the eastern basin of Lake Erie, 1996–2000.

Thermal Stratum		***1996***	***1997***	***1998***	***1999***	***2000***	***Total 1996 - 2000***
Epilimnion	# of tows	4	4	6	2	10	26
	# of YAO fish collected	1,867	901	15	508	2,627	5,918
	% YAO smelt	98.5 %	80.0%	73.3%	99.6%	85.5%	89.1%
Metalimnion	# of tows	4	4	3	4	9	24
	# of YAO fish collected	3,880	4,847	2,829	2,151	9,579	23,286
	% YAO smelt	97.4 %	97.9%	99.6%	99.3%	99.8%	98.9%
Hypolimnion	# of tows	1	2	1	2	7	13
	# of YAO fish collected	107	3,796	1,428	6,529	14,920	26,781
	% YAO smelt	97.2%	>99.9%	99.7%	>99.9%	>99.9%	>99.9%

Table 5.1.2. Estimated minimum numeric abundance index of YAO smelt-sized fish (TS of -55 to -43 dB) in cold water habitat in the eastern basin of Lake Erie during July 2000. Confidence limits (95%) are the percent of the total abundance estimate.

Depth Strata	**Total Numeric Abundance**	**(95 % Confidence Limit as % of mean)**
18 to 25 m	96,776,384	49.64%
25 to 35 m	367,854,809	22.37%
> 35 m	504,131,777	16.49%
TOTAL	968,762,970	9.83%

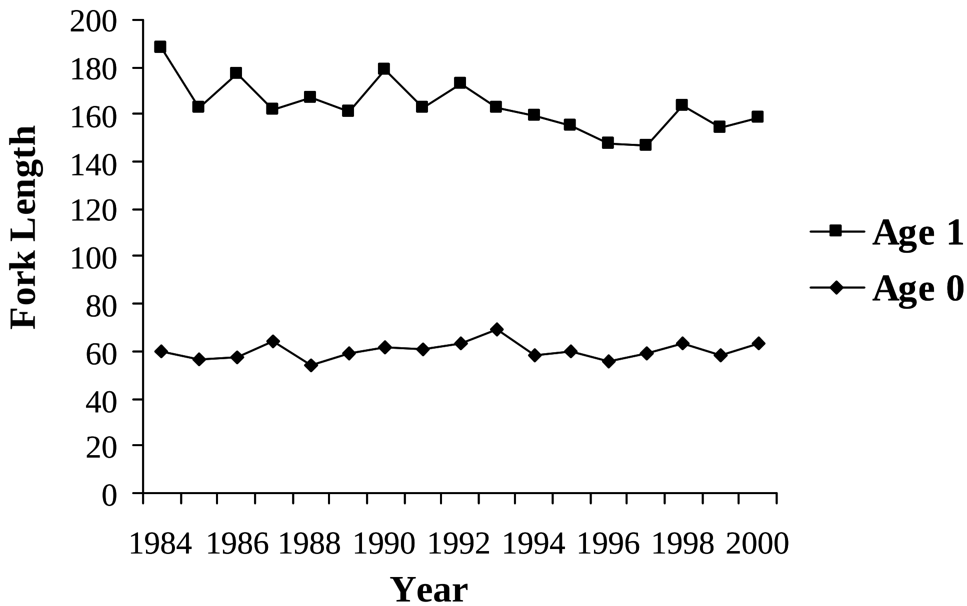


Figure 2.1 Mean fork length of age-0 and age-1 rainbow smelt from OMNR index trawl survey in Long Point Bay, Lake Erie, October 1984-2000.

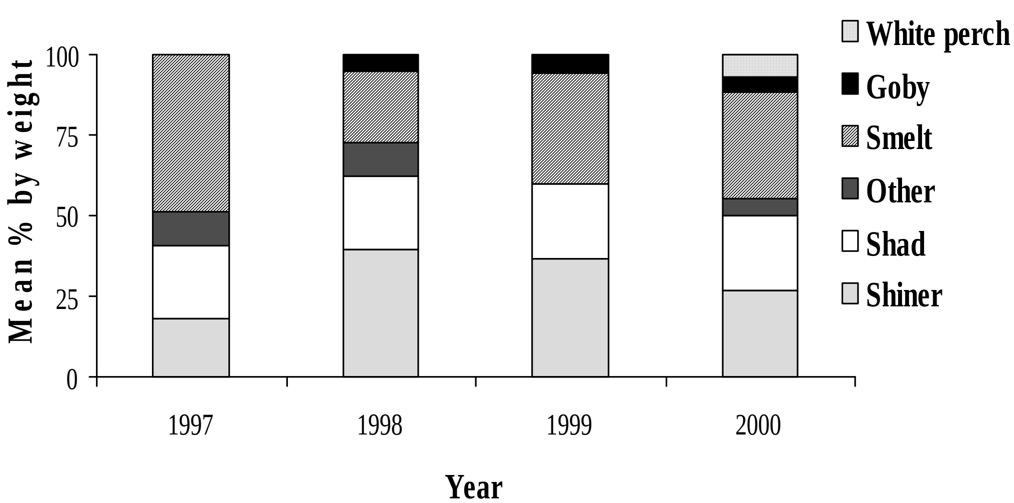


Figure 2.2 Diet composition (mean % by weight) of adult walleye from fall bottom trawl surveys in the central basin, Lake Erie, 1997-2000.

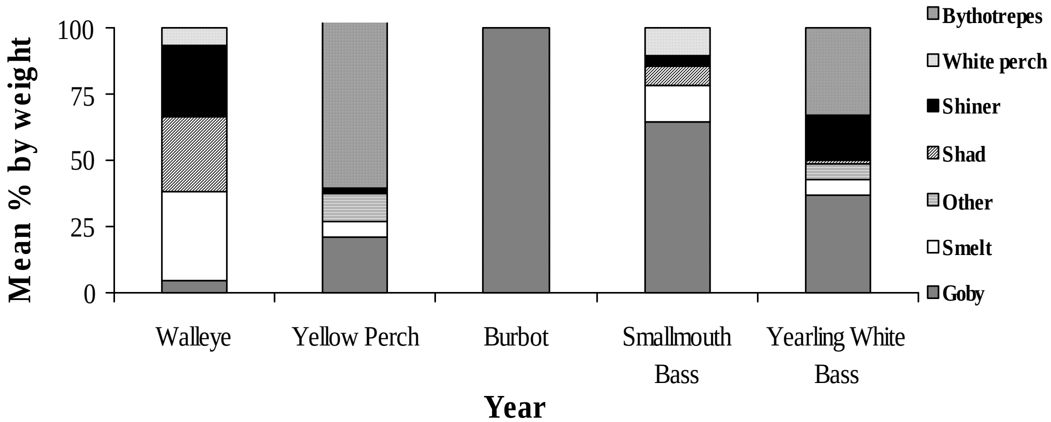


Figure 2.3 Diet composition (mean % by weight) for selected species from Ohio fall bottom trawl surveys in the central basin, Lake Erie, 2000.

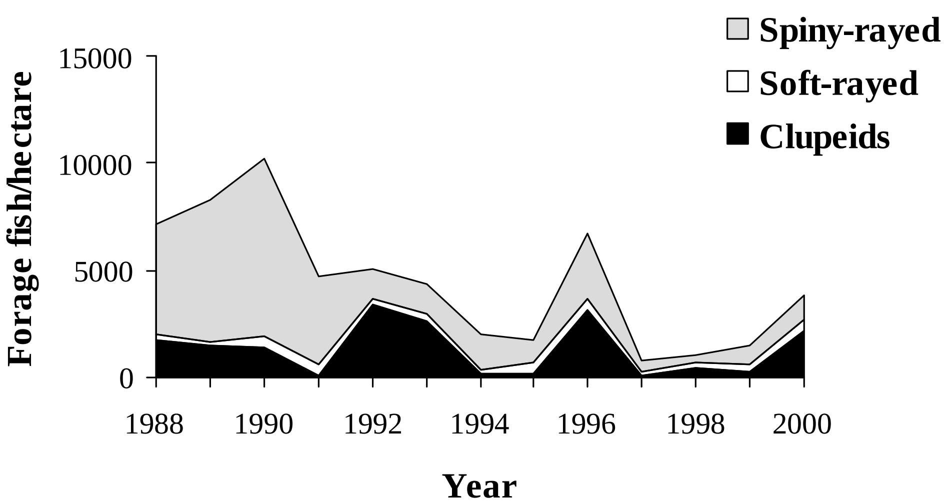


Figure 2.4. Mean abundance (#/hectare) of functional prey fish groups in Ontario waters of the western basin, Lake Erie, 1988-2000.

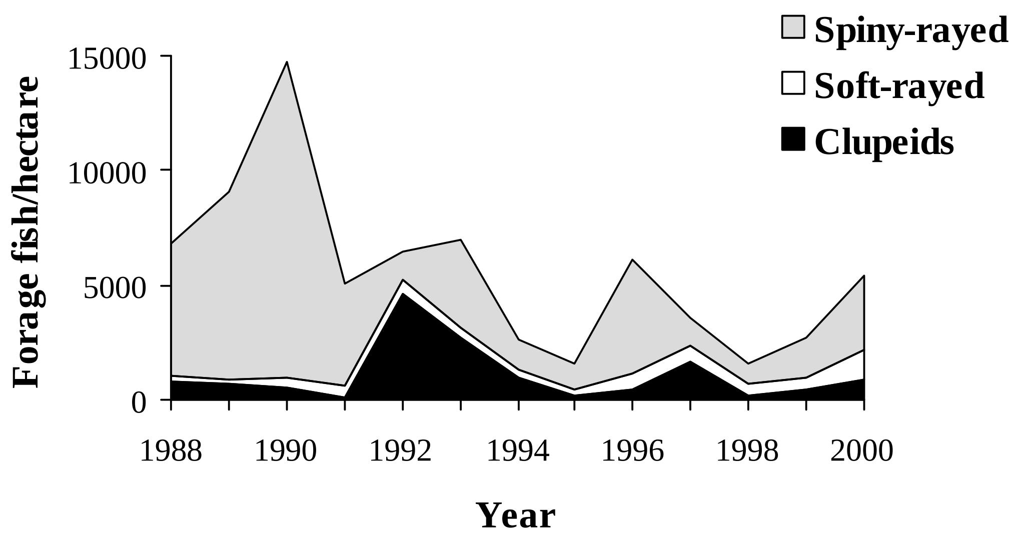


Figure 2.5. Mean abundance (#/hectare) of functional prey fish groups in Ohio waters of the western basin, Lake Erie, 1988-2000.

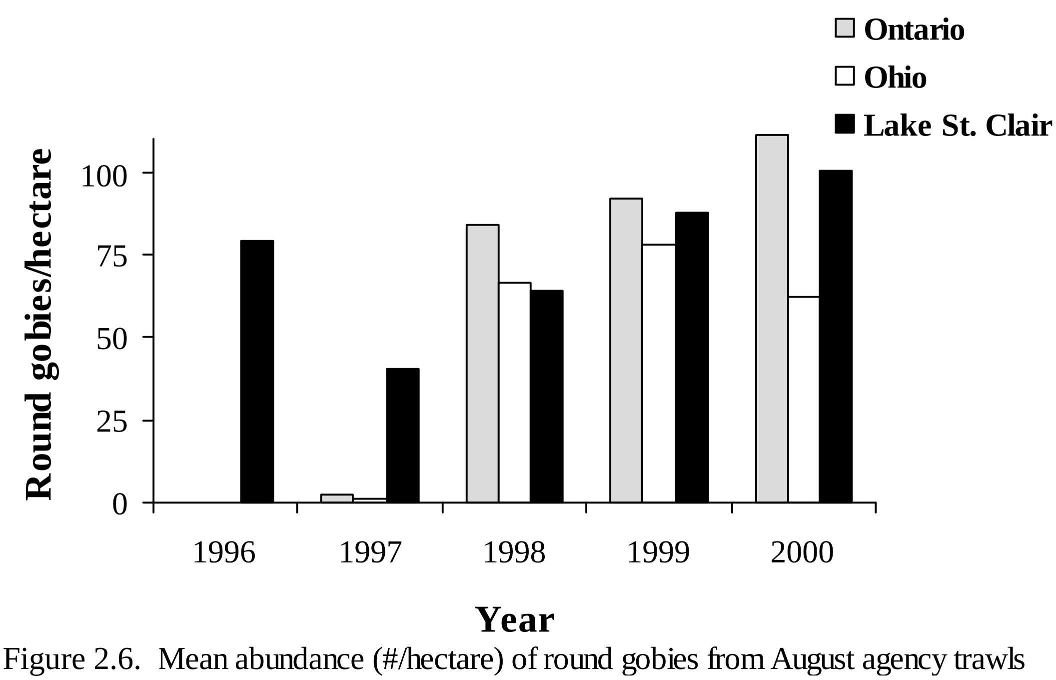


Figure 2.6. Mean abundance (#/hectare) of round gobies from August agency trawls in Lake St. Clair and the western basin of Lake Erie, 1996-2000.

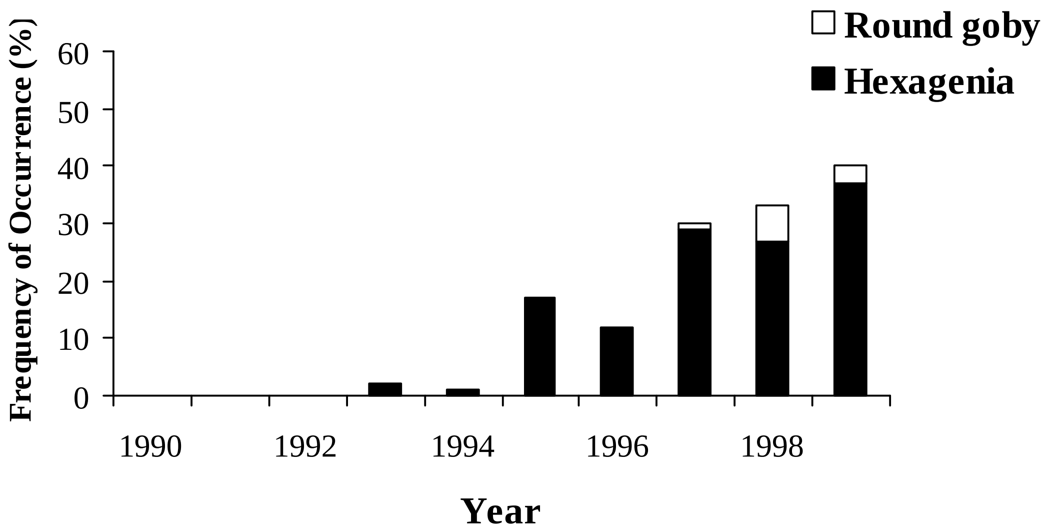


Figure 2.7. Percent *Hexagenia* and round goby in the diets of yellow perch collected in Ohio waters of the western basin, Lake Erie, 1990-1999.

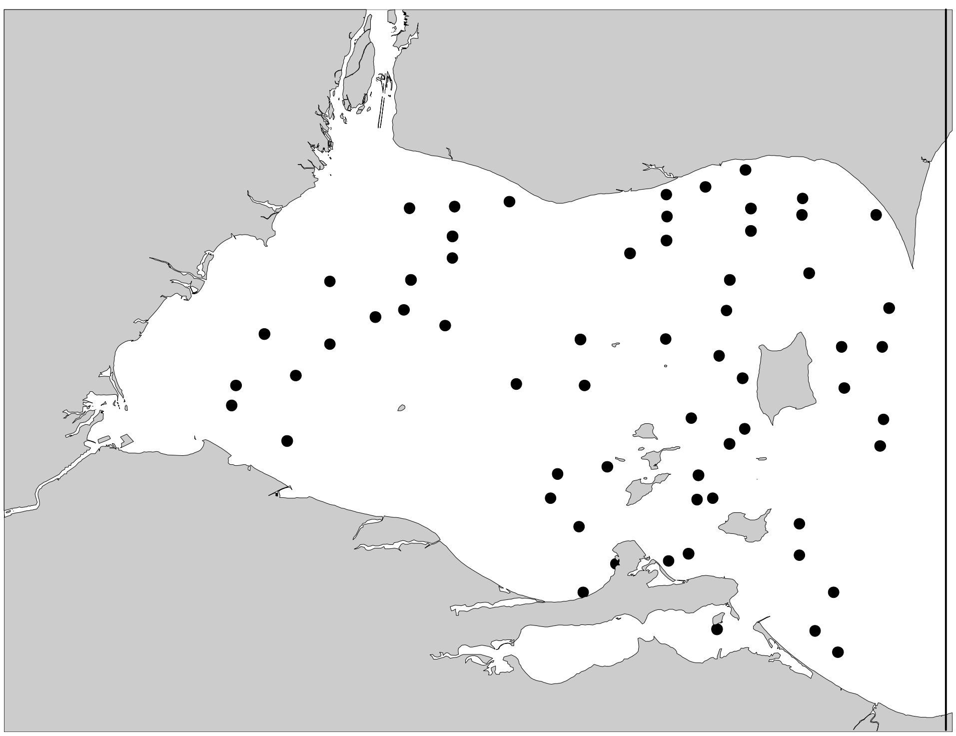


Figure 3.1. Trawl locations for western basin interagency trawl survey, August, 2000.

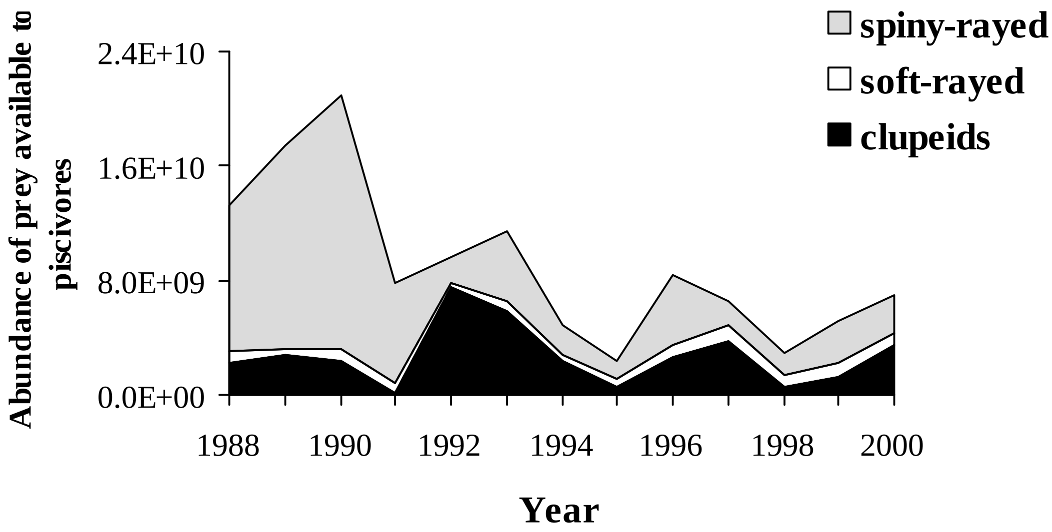


Figure 3.2. Estimated absolute abundance of prey fish by functional category in waters of the western basin, Lake Erie, 1988-2000.

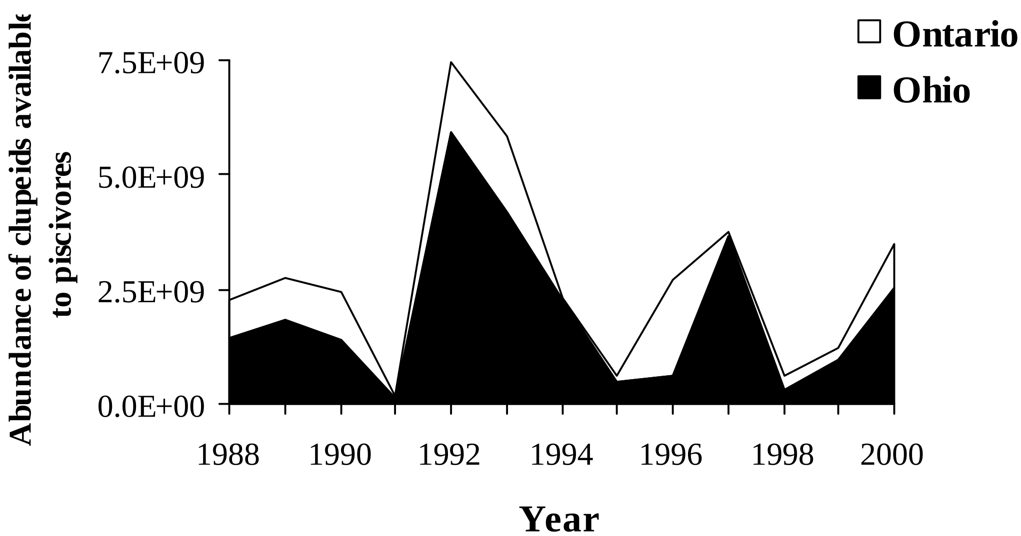


Figure 3.3. Estimated absolute abundance of clupeids in Ohio and Ontario waters of the western basin, Lake Erie, 1988-2000.

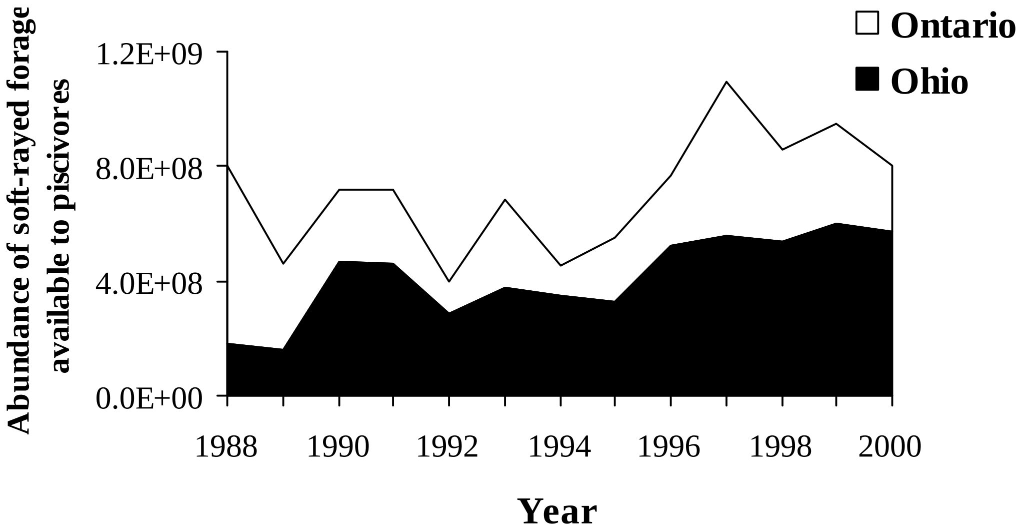


Figure 3.4. Estimated absolute abundance soft-rayed forage in Ohio and Ontario waters of the western basin, Lake Erie, 1988-2000.

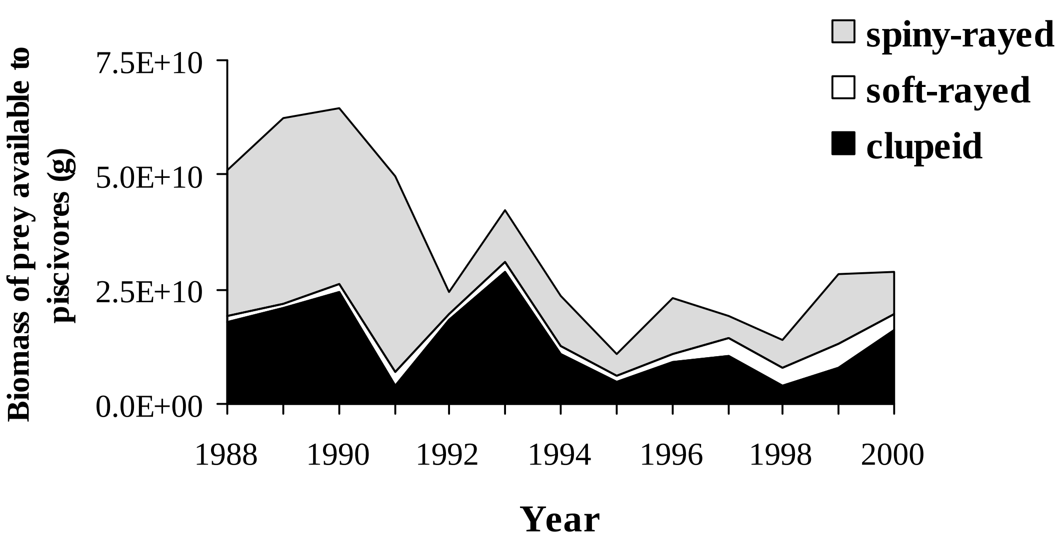


Figure 3.5. Estimated absolute biomass of prey by functional category in waters of the western basin, Lake Erie, 1988-2000.

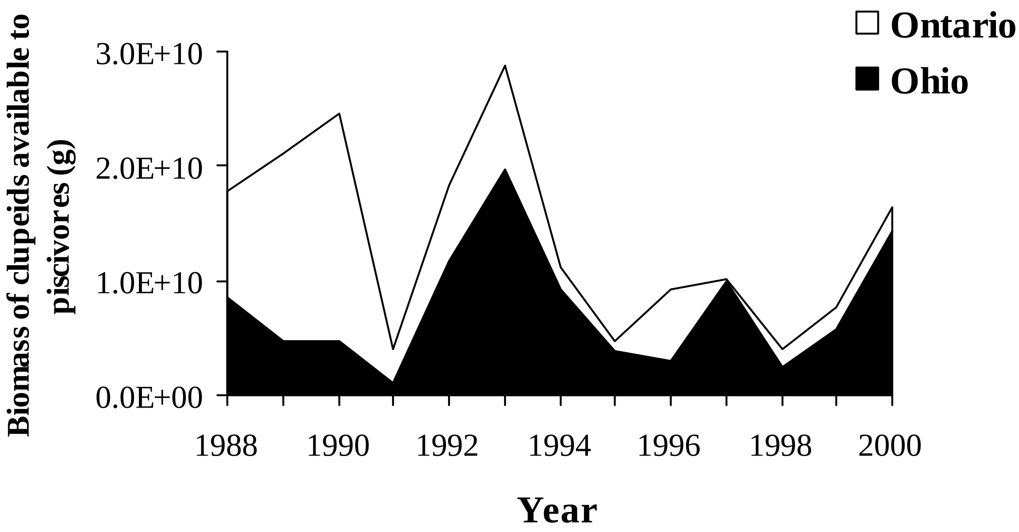


Figure 3.6. Estimated absolute biomass of clupeids in Ohio and Ontario waters of the western basin, Lake Erie, 1988-2000.

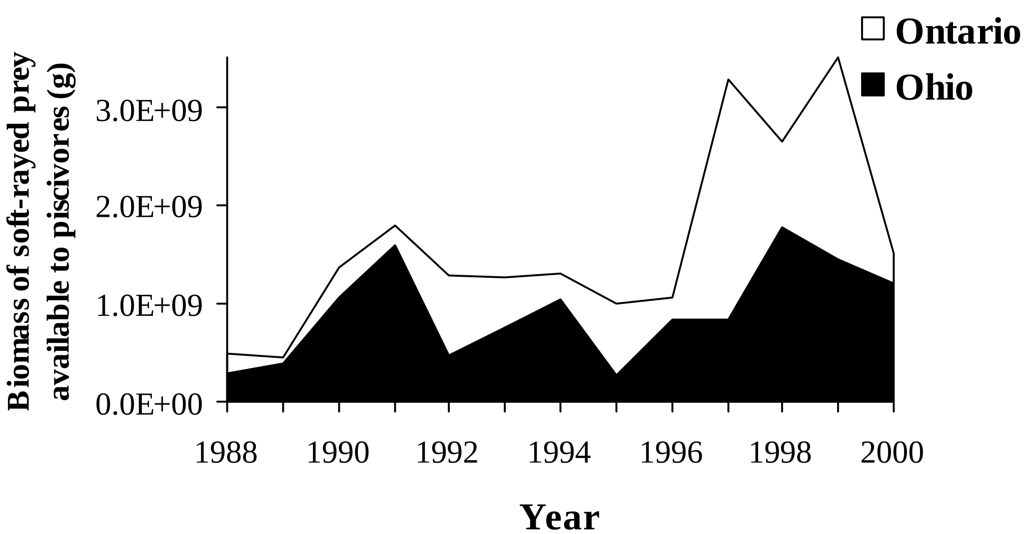


Figure 3.7. Estimated absolute biomass of soft-rayed prey in Ohio and Ontario waters of the western basin, Lake Erie, 1988-2000.

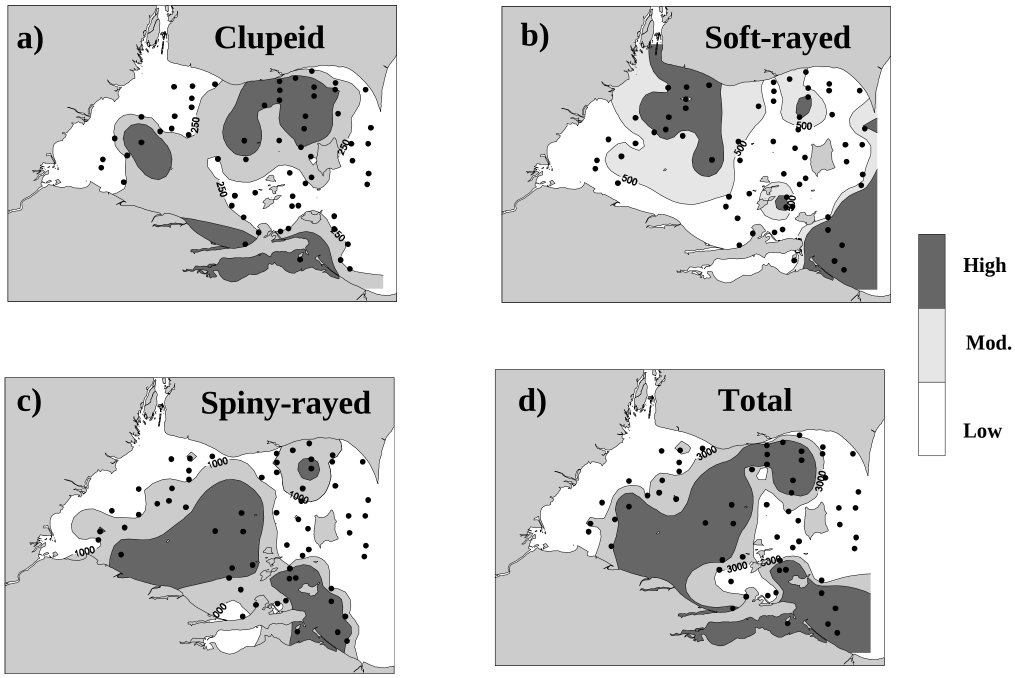


Figure 3.8. Spatial distribution of clupeids (a), soft-rayed forage (b), spiny-rayed forage (c), and total forage (d) in western basin of Lake Erie, August, 2000. Contour levels vary for each functional prey category and are noted on each figure.

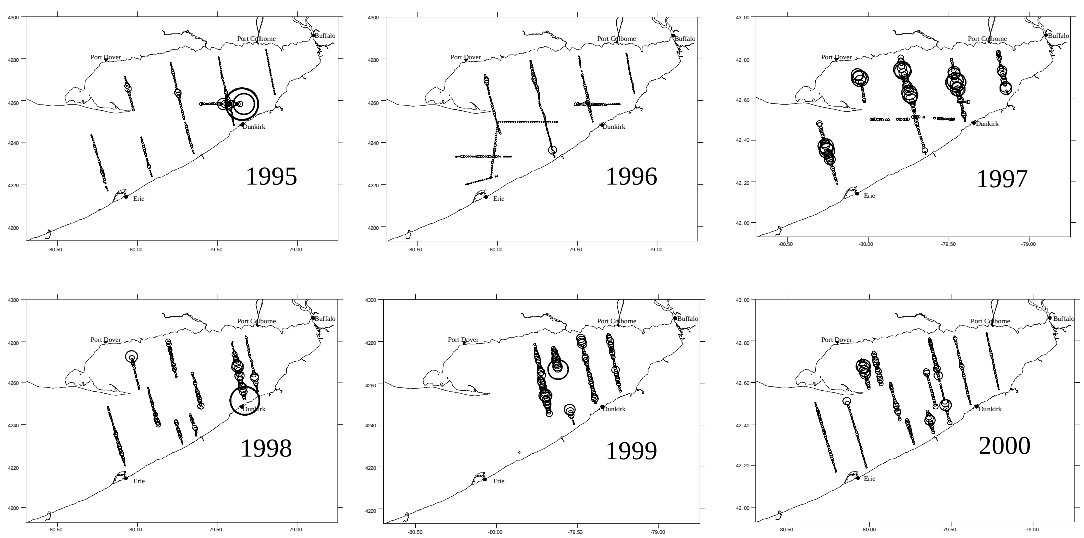
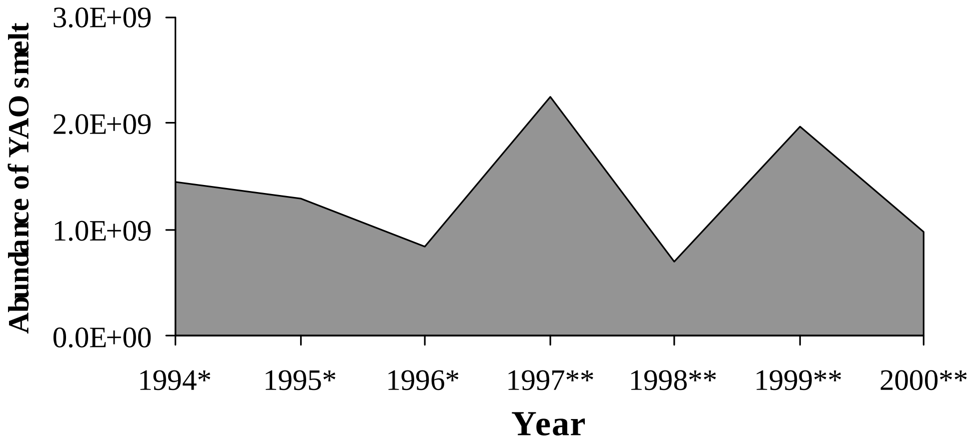


Figure 5.1.1. Sampling locations and relative density of pelagic, adult forage-sized fish during July, 1995 to 2000 fisheries acoustic surveys.



* - 1993 to 1996 data was extrapolated from 70 kHz single beam echosounder for target strength range of -56 to -44 dB,
** - 1997 to 2000 data was extrapolated from 120 kHz split beam echosounder for target strength range from -55 to -43 dB

Figure 5.1.2. Eastern basin, July index of yearling-and-older pelagic forage fish estimate obtained from annual summer acoustic surveys.

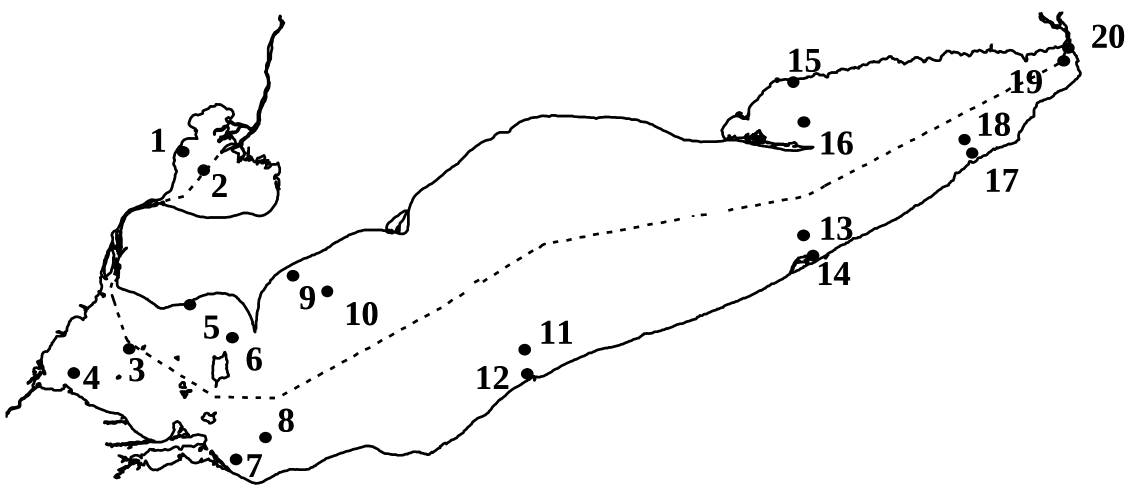


Figure 6.1. Lower Trophic Level sample stations in Lakes Erie and St. Clair, 2001.

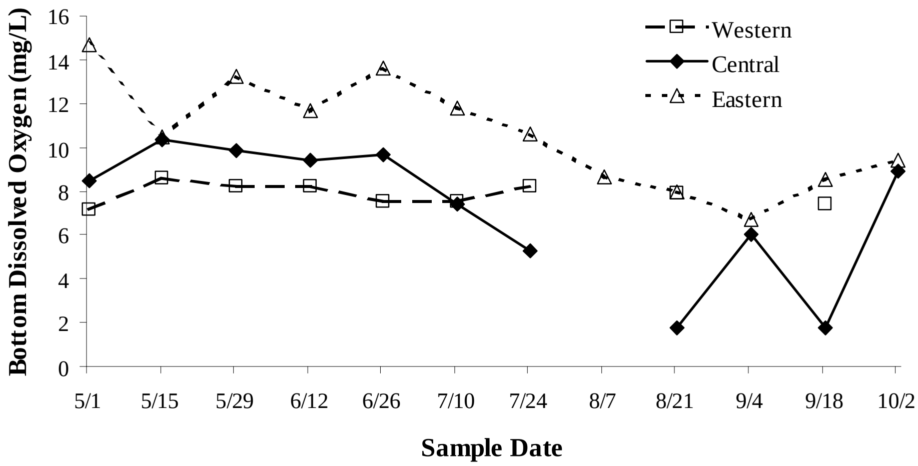


Figure 6.2 Mean bottom dissolved oxygen (mg/l) for each basin on each sampling date, 2000. Values are means of measurements recorded within each basin. West basin, sites 3-6; Central basin, sites 7-14; East basin, sites 15-20.

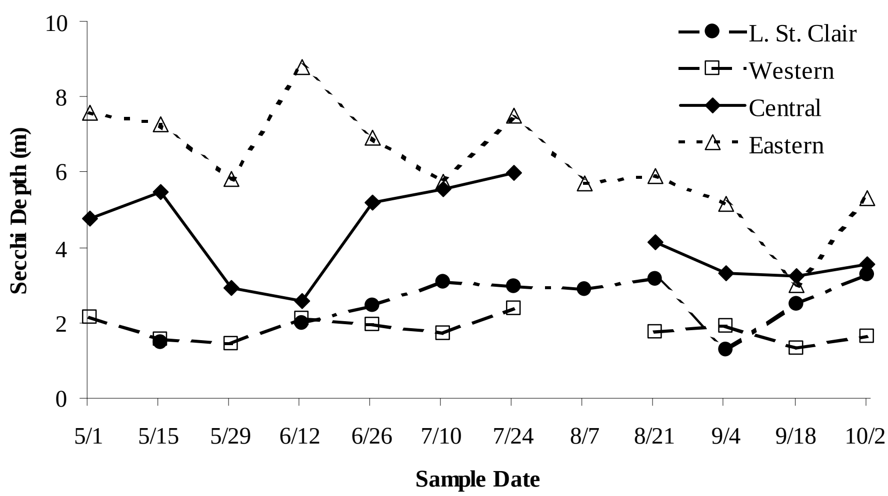


Figure 6.3 Mean secchi depths (m) from interagency lower trophic sampling by date for each Lake Erie basin and Lake St. Clair, 2000

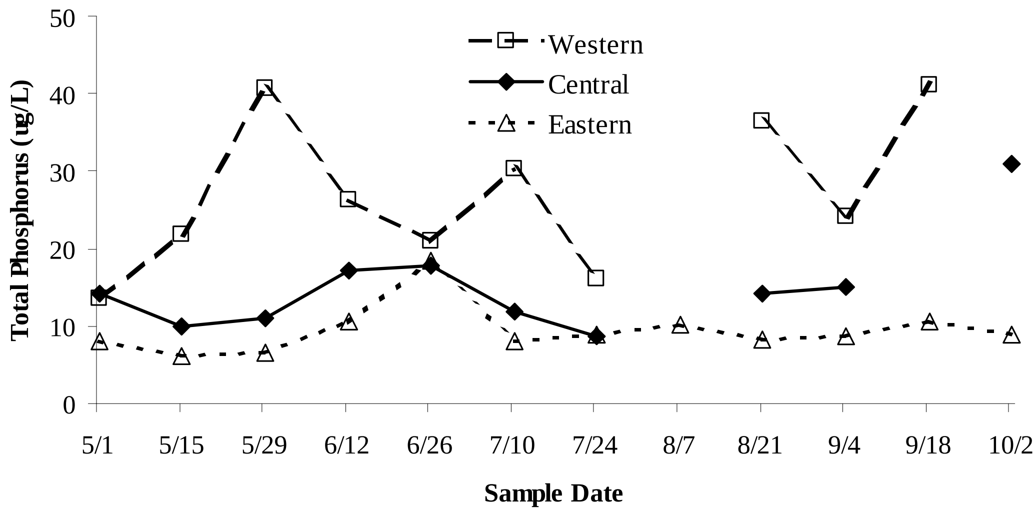


Figure 6.4 Mean weekly total phosphorous (ug/l) from interagency lower trophic level sampling by date and basin, Lake Erie, 2000.

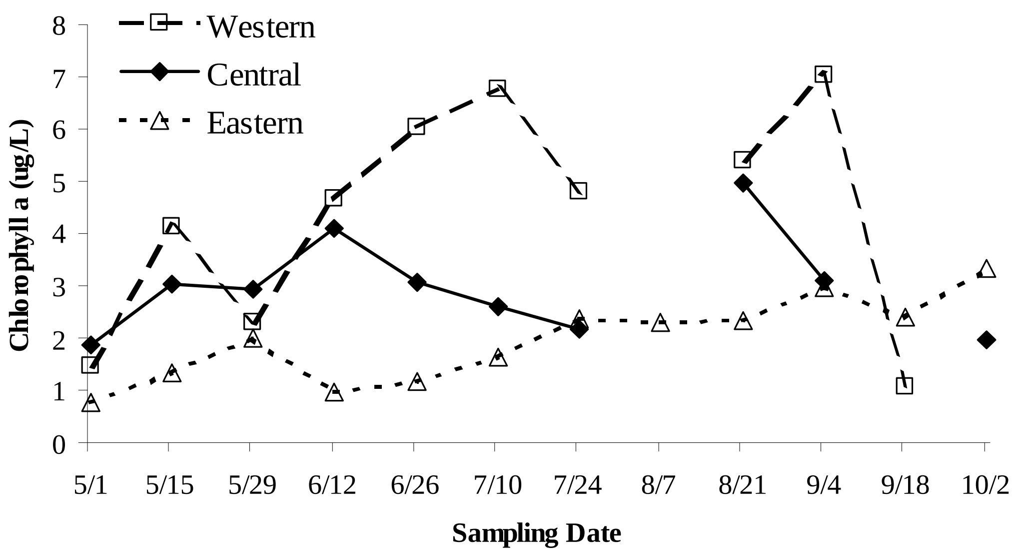


Figure 6.5 Mean weekly chlorophyll a levels (ug/l) from interagency lower trophic level sampling by date and basin, Lake Erie, 2000.

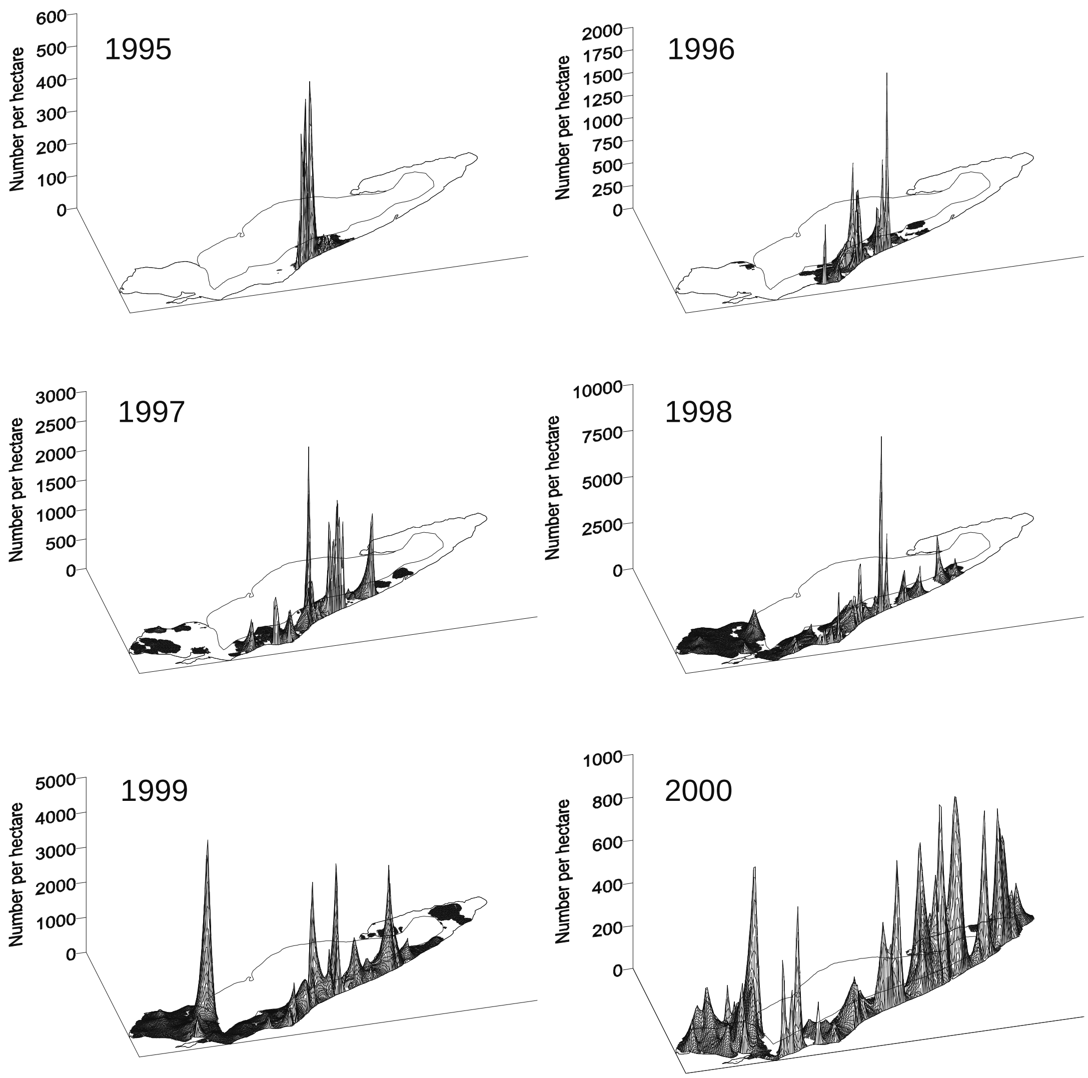


Figure 7.1 Round Goby distribution and abundance from interagency bottom trawls in Lake Erie, 1995-2000.