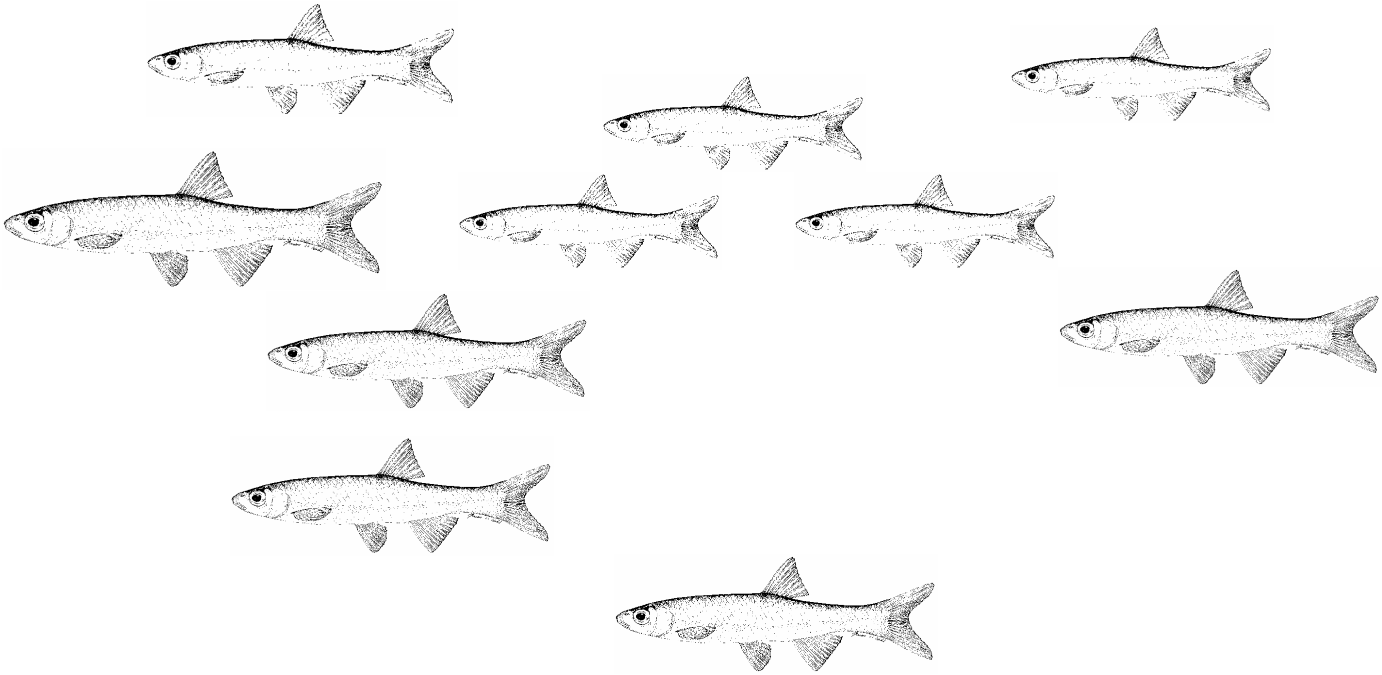
Report of the
Lake Erie
Forage Task Group

March 2003



Members:

John Deller	- Ohio Department of Natural Resources, (ODNR) {Co-chair}
Betsy Trometer	- United States Fish and Wildlife Service, (USFWS) {Co-chair}
Mike Bur	- United States Geological Service - Biological Resources Division (USGS)
Don Einhouse	- New York Department of Environmental Conservation, (NYS DEC)
Bob Haas	- Michigan Department of Natural Resources, (MDNR)
Tim Johnson	- Ontario Ministry of Natural Resources, (OMNR)
Jim Markham	- New York Department of Environmental Conservation, (NYS DEC)
Chuck Murray	- Pennsylvania Fish and Boat Commission, (PFBC)
Mike Thomas	- Michigan Department of Natural Resources, (MDNR)
Jeff Tyson	- Ohio Department of Natural Resources, (ODNR)
Larry Witzel	- Ontario Ministry of Natural Resources, (OMNR)

Presented to:

Standing Technical Committee
Lake Erie Committee
Great Lakes Fishery Commission

Table of Contents

1.0 Charges to the Forage Task Group in 2002-2003

1. Continue to describe the status and trends of forage fish species and invertebrates in 2002/2003 for each basin of Lake Erie.

2. Continue the development of an experimental design to facilitate forage fish assessment and standardized interagency reporting.

3. Continue the fisheries acoustics program to assess pelagic forage fish stocks in the eastern basin. Continue pilot survey investigations using the Lake Erie acoustic system in the central and western basins of Lake Erie.

4. Continue the interagency lower-trophic monitoring program that produces annual indices of trophic conditions which can be included with the FTG's annual description of forage status.

5. Identify efficient hydroacoustic sampling design from research done in association with Lars Rudstam and Cornell U., and apply.

6. Extend survey to include inshore waters that provide forage for top predators, to extent feasible using acoustic gear (additional transects, extend transects).

2.0 Forage Task Group Bullet Statements

Eastern Basin (by L. Witzel, D. Einhouse, J. Markham and C. Murray)

- Rainbow smelt are the principal forage fish species of piscivores in the offshore waters of eastern Lake Erie (Table 2.1). Yearling-and-older (YAO) smelt (predominately age-1) have demonstrated a conspicuous alternate year cycle of increased abundance as evidenced in index bottom trawl surveys conducted annually by OMNR and NYS DEC. A decrease in YAO smelt abundance was expected in 2002, and indeed was the observed outcome among all of the agency trawl surveys. The decrease was most evident in OMNR trawl catches, which produced the lowest YAO abundance index observed in the 19-year history of this survey. Young-of-the-year (YOY) smelt have remained as the most abundant forage fish component in the absence of an abundant yearling cohort of smelt. YOY smelt abundance decreased basin-wide in 2002. The decrease in abundance however was more pronounced in the northern versus southern regions of the East Basin. Densities of Age 0 smelt were approximately 10 times higher in the NYS DEC survey areas compared to Long Point Bay (OMNR). Mean length of Age 0 smelt decreased in 2002 for the second consecutive year (Figure 2.1). In contrast, during this same time span, the average length of yearling smelt increased. Size of yearling smelt in OMNR's index trawl collections during 2002 was the highest observed since 1990.

- Several other species made significant contributions to the forage fish community of eastern Lake Erie in 2001 and to a lesser extent in 2002 (Table 2.1). Most notable non-smelt forage fish components that contributed to species diversity of eastern Lake Erie's fish community were YAO emerald shiner, YAO spottail shiner, YOY alewife, trout-perch and round goby. YOY alewife was the third most abundant forage fish component collected during the 2002 NYS DEC trawl survey. Alewife were uncharacteristically abundant in companion mid-water trawl collections conducted during the July 2002 hydroacoustic assessment of the east basin pelagic fish community (Section 4.1). Trout-perch continued to be a prominent component of the benthic fish community in southern regions of eastern Lake Erie, but remained conspicuously sparse throughout the Long Point Bay area.

- Round gobies emerged as a new species among the eastern basin forage fish community during the late 90's. Gobies continued to increase in density at a rapid rate and by 2001 became the most or second most numerically abundant species caught in agency index trawl gear across areas surveyed in eastern Lake Erie. In 2002, round goby population growth made an abrupt reversal. With one exception (ON-DW trawl survey, Table 2.1), density of gobies decreased basin wide during the most recent year of agency assessments.

- During 2002, NYS DEC and OMNR continued to participate in the eastern basin component of the lake-wide inter-agency Lower Trophic Level Assessment (LTLA) program coordinated through the Forage Task Group. These data have been incorporated in the Forage Task Group's LTLA database.

- Examination of angler-caught adult walleyes revealed that rainbow smelt have remained the dominant prey of walleyes during each summer of assessment (NYS DEC) since 1993. An examination of stomach contents from lake trout and burbot caught during experimental gill net surveys in the eastern basin of Lake Erie, August 2002, revealed diets comprised almost exclusively of fish in both of these coldwater predators. Rainbow smelt remained the most abundant prey item, occurring in over 90% of lake trout and 42% of burbot stomachs. Round gobies were observed for the first time in lake trout and increased from 22% in 2001 to 30% in 2002 in burbot. The abundance of clupeids in the lake was evident in the diets of both species.

- Age-2 and age-3 smallmouth bass cohorts sampled in 2002 autumn gill net collections were both longer than average for New York's 22-year time series. Age-1 walleyes in the autumn gill net collections were near the long-term mean total length for this same 22-year time series. Few age-2 walleyes were collected in 2002; nevertheless age-2 walleye length-at-age continued a trend of increasing length-at-age observed for walleyes since 1999. Lake trout continued to grow at or above long-term (1985 – 2000) averages through age 7, but remained consistent in the older age classes.

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

- In the central basin, overall forage abundance declined from 2001 (Table 2.2; 2.3). In both Ohio and Pennsylvania, for all species combined, the 2002 cohort was one of the smallest in the time series. Only alewife abundance increased basin wide. In Ontario, a clupeid index of forage generated from the small mesh gillnets (32, 38 and 44mm gillnets, OMNR / OCFA Partnership program) showed a marked increase in 2002 (95.3 / site) relative to 2001 (21.94) and the long-term mean (48.5). 2002 was the third highest clupeid CPUE in the 13-year program. The only other species to increase from 2001 in Pennsylvania were emerald shiners, trout-perch and white perch, and in Ohio were rainbow smelt, and round goby. YAO forage abundance generally increased from 2001 and was above the long-term average in both Pennsylvania and Ohio. The only YAO decreases in abundance estimates from 2001 occurred in white bass and yellow perch in Pennsylvania and round goby in Ohio.

- In the Pennsylvania waters of the central basin, YOY round goby abundance declined dramatically from 2001, which was the highest abundance recorded since the round goby entered Pennsylvania. An opposite trend occurred in the Ohio waters where the young-of-year indices increased slightly from 2001 in both ODNR and USGS trawl surveys. YOY round goby abundance in both Ohio and Pennsylvania are well below the long-term average. Yearling-and-older round goby abundance in Ohio declined to half the numbers seen in 2001. There has been a general decline in round goby abundance in Ohio since 1997, when the peak abundance occurred. In the Pennsylvania waters of the central basin, yearling-and-older abundance increased dramatically from 2001, to the highest abundance recorded during the time series. There was a similar east to west trend in yearling-and-older abundance in Ontario waters in 2002. Goby CPUE from the small mesh bottom set gillnets (OMNR / OCFA Partnership program) showed a marked increase in the east-central basin (4.22 gobies per set vs 0.88 in 2001), while catches in the west-central declined (0.26 vs 0.37) for the fourth straight year.

- Mean size of forage species generally declined slightly in 2002. Only YOY white bass increased dramatically from 2001, to the largest size in the time series.

- Yellow perch and white perch diets were collected by USGS in the summer and fall in the west-central basin (mean percent volume). The diets of both species were comprised mainly of *Bythotrephes* in the summer (YP= 73%; WP= 21%), switching to mostly fish in the fall (YP= 69%; WP= 70%), with lesser contributions of *Bythotrephes* (YP= 13%; WP= 1%), *Leptodora (YP= 6% ; WP= 6%)* and zebra mussels (YP=6%; WP= 3%). Additional diet information in the central basin (percent dry weight) was collected by ODNR-Fairport. Adult walleye diets in the fall were dominated by clupeids (81.3%) and smelt (12.5%). Round goby were consumed by walleye in the spring (42%) and summer (100%), but were not present in the fall adult diets. The increase in clupeid consumption from 2001 is likely due to the forage abundance in the west-central basin where the majority of walleye diet samples were collected. The fall yellow perch diets continue to be primarily round goby (39.1%), chironomids (25.5%), and Bythotrephes (17.3%). Round goby were significant diet items in smallmouth bass (75.8%), white bass (25.0%), catfish (38.5%) and white perch (20.4%).

- Lower trophic level sampling was conducted at six sites in the central basin. Oxygen concentration in the hypolimnion fell below 4 mg/L in late July and extended to early September at some sites. Secchi depth was lower in 2002. Total phosphorous concentrations were lower while chlorophyll a concentration was higher in 2002.

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

- Percid recruitment was the worst since the survey began in 1987. Clupeid CPUE declined marked in the northern half of the basin (gizzard shad down 50-fold, second lowest in series; alewife half of 2001), while clupeid CPUE increased marginally in the southern half of the basin (Figures 2.2 and 2.3). Both age-0 and yearling-and-older emerald shiner CPUE increased in 2002. Spottail shiner abundance declined significantly in Ontario waters (lowest since 1987) and the USGS survey, but remained near the long-term average in the Ohio survey. YOY smallmouth bass CPUE was the highest in time series (up 5-fold from 2001) while most other species declined. In August, all surveys showed a decline in YOY white bass and white perch (except USGS East Harbor sites), while October surveys in Ohio showed moderate abundance of *Morone* sp.

- Round goby CPUE increased from 2001, to similar levels seen in 2000. These trends suggest the population may be stabilizing. Trawls are conducted on soft sediments only (not preferred goby habitat) so density estimates are very conservative (Figure 2.4).

- Age-0 yellow perch size declined in 2002, falling below the long-term average for the first time in 5 years. As has been evident in previous years, age-0 yellow perch were smaller in Ontario waters than in Ohio waters. Age-1 and age-2 yellow perch were also smaller than in 2001. However, age-2 walleye mean length and weight were near record levels, possibly due to low abundance. Insufficient age-0 walleye were caught to accurately evaluate their size.

- Yellow perch collected near East Harbor State Park consumed zebra mussels in the summer (88% by volume) and fall (30%). Fish and *Leptodora kindtii* were also important prey in the fall diets of yellow perch. Fall walleye diets collected from gill nets continued to be comprised of clupeids (95%) with shiners and gobies also contributing. White perch stomachs were dominated by fish in the summer (42%) and fall (68%), with notable contributions of chironomids and zebra mussels in the summer, and *Leptodora* and *Hexagenia* in the fall.

- On average, water temperatures were slightly warmer in 2002 than in 2001 with a three week period beginning in July where surface temperatures exceeded 25 C. Oxygen concentrations remained high throughout the year in Ontario waters, while relatively low dissolved oxygen levels (2.7-3.8 ug/L) occurred in Ohio waters in the first week of July. Secchi depth was marginally higher in 2002 (3.0m seasonal average) than in 2001 (2.37m) in Ontario waters as well as offshore Ohio waters. Little change was seen in total phosphorous concentration (~0.0225 mg/L seasonal average) in Ontario waters and offshore Ohio waters or chlorophyll a (~7.6 mg/L) between 2001 and 2002. Total phosphorus concentrations in nearshore Ohio waters was similar to those seen 2001 (~0.048 mg/L seasonal average), while chlorophyll a concentration declined slightly (~7.5 mg/L). *Hexagenia* abundance near East Harbor was the lowest since the survey began in 1997.

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 2002, Ohio is planning to use the SCANMAR equipment to measure trawl configuration aboard the new RV Explorer.

Each year demand for the SCANMAR equipment increases. Currently, the equipment is available to the Lake Erie agencies for only a couple of weeks a year, when it is not committed to other Great Lakes projects. In 2002, the Forage Task Group submitted a Coordinated Activities Program proposal to purchase a net mensuration system that would be dedicated to agencies on Lake Erie. A dedicated system would ease the scheduling conflicts with the current system, and enable agencies to collect more accurate data on bottom and midwater trawl performance. The system would also improve the quantification of ground truth operations for annual hydroacoustic surveys in the central and eastern basins.

3.2 Summary of Species CPUE Statistics

(by T. Johnson and J. Tyson)

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 74 trawls were used in the analyses in 2002 (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. In 2002, ODNR began interagency trawling with the new vessel *R.V Explorer II*. Due to time constraints, the SCANMAR equipment was not employed on the new research vessel. Net dimensions from the 1997 SCANMAR exercise were applied to the new ODNR vessel with the intent of employing the SCANMAR equipment on the new vessel during the summer of 2003.

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*

Exercise 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 Exercise* section below.

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. Arithmetic mean 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, gear biases discussed above must be considered when interpreting basin-wide absolute estimates of fish abundance and biomass.

Total forage abundance and biomass decreased in the western basin in 2002, relative to 2001, owing primarily to decreases in the catch of spiny-rayed fishes in both Ohio and Ontario waters (Figures 3.2 and 3.5). In contrast to 2001, clupeids were the dominant prey group collected in 2002 bottom trawls, followed closely by spiny-rayed fishes, then soft-rayed fishes (Figure 3.2 to 3.4). Despite slightly higher estimates of abundance for clupeids in the western basin, biomass declined slightly in 2002 (Figure 3.6). This is mainly attributable to the relatively small size of gizzard shad in August of 2002 (TL=76 mm) as compared to other years in the series (long-term average TL=87 mm). The large contribution of clupeids from Ohio relative to Ontario is likely a consequence of basin morphometry. Ohio sampling stations are more evenly distributed between depth strata, whereas Ontario has a very high proportion of deeper water, where the bottom trawls are more apt to underestimate the contribution of pelagic fishes like clupeids. Despite apparent increases in emerald shiners in both Ohio and Ontario waters of the west basin, soft-rayed forage abundance and biomass declined in 2002, relative to 2001 (Figure 3.4 and 3.7). This is most likely a function of lower abundance of age-0 and older spottail shiners, as well as lower abundance of trout-perch in the 2002 samples. Changes in biomass for the other functional forage groups were proportional to those seen in abundance (Figure 3.5 to 3.7). Walleye and yellow perch year-classes were both very poor, with average to below average production for gizzard shad, white perch, white bass, and freshwater drum. The only apparent increases in production were associated with age-0 and older emerald shiners, as well as age-0 smallmouth bass, which do not contribute significantly to the overall forage fish abundance or biomass.

Spatial maps of forage distribution were constructed using site-specific catches (#/ha) of the functional forage groups. Abundance contours were generated using kriging contouring techniques to interpolate abundance between trawl locations. Abundance of clupeids was highest in the south central portion of the basin extending up the west side of the island archipelago (Figure 3.8a). This pattern has been seen in previous years and suggests the area influenced by the Maumee River in the west basin is preferred by gizzard shad. Soft-rayed fish (predominantly emerald shiners and trout-perch) were most abundant in the northwest portion of the basin (Figure 3.8b). This pattern is similar to that seen in the previous few years. Spiny-rayed abundance was predominately age-0 white perch and white bass. Peak abundance was seen in the central portion of the basin generally west of the island archipelago (Figure 3.8c). Total forage abundance averaged 2,500 fish/ha across the western basin, nearly half of abundance of 2001. Clupeids averaged 1,100 fish/ha, soft-rayed fishes averaging 520 fish/ha, and spiny-rayed fishes averaging 900 fish/ha. The largest declines were associated with spiny-rayed fish abundance.

3.3 Trawl Comparison Exercise (by J. Tyson and T. Johnson)

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 its true fishing configuration (height and width of mouth opening); but does not address other potential differences between agency trawling programs. The procedures for addressing these issues were outlined at a workshop conducted in August 2000 by the Forage Task Group, in conjunction with the Ohio Chapter of the American Fisheries Society. Results of the workshop were reported in the 2000 Forage Task Group Report.

Due to extremely poor recruitment of age-0 percids, the comparative trawling experiment was not undertaken in 2002. Because the primary target of the interagency bottom trawling series is age-0 percids, and low abundance would effectively reduce the comparative trawling sample sizes, the exercise was rescheduled for 2003. Additionally, since 2002 was the first year of operation for ODNR's new research vessel, postponement of the exercise allowed ODNR personnel to work out most of the operational/equipment issues and adjustments on the new vessel prior to the comparative trawling exercise. The comparative trawling exercise has been tentatively rescheduled for the week of August 25th-29th, 2003 at one of two grids in the west basin near South Bass Island (Figure 3.9). These two grid locations represent areas where historical catches of percids has generally been high, therefore these locations would theoretically maximize the percid catch, and the number of hauls available for comparison. Lodging and dockage will be provided by ODNR on South Bass Island to minimize travel time.

4.0 Acoustic Survey Program

(by L. Witzel, and D. Einhouse)

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 2002. 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. After 1999, only the long-term July acoustic survey was continued to monitor pelagic forage fish density and distribution in eastern Lake Erie. During September 2000 and August 2001, additional survey transects were sampled in the central basin of Lake Erie as a new initiative. Over the time series of this program, data collection has been coordinated among Forage Task Group member agencies with several research vessels (Argo, Erie Explorer, Kennosay and Perca) participating in various aspects of the data collection and calibration.

Data analysis has been principally coordinated between the Ontario Ministry of Natural Resources and New York State Department of Environmental Conservation. Only the ongoing July acoustic survey results from the inception of this survey through 2001 are presented in this report as the long-term abundance index for eastern basin pelagic forage fish that has been underway since 1993. Analysis and discussion of the 2002 acoustic survey results have been deferred until Forage Task Group can convene a workshop to analyze results encompassing the entire 10-year time series of this ongoing acoustic survey program.

Methods

The 120 kHz split beam echo sounder is calibrated at the beginning of the annual July eastern basin survey. Acoustic signals are annually processed/analyzed using the EY500/EP500 analysis software (version 5.5, Simrad 2000). 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 echoes within each target strength bin. 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 the entire 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 generally 85 to 95% of comparable estimates produced from split beam systems, we have not yet applied any scaling factor for comparing 1993-96 single beam and subsequent split beam results.

Data acquisition throughout our acoustic survey efforts 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 are 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

A companion mid-water trawl survey has always accompanied the acoustic sampling in eastern Lake Erie. In 2001 the trawling was conducted aboard the *RV Argo* using a mid-water trawl with fishing dimensions of 36 m^2. All trawl samples were counted by species and sub-samples of each collection were measured for total length.

Results and Discussion

The July 2001 acoustic survey suggested a pattern of YAO pelagic fish abundance dissimilar from most previous efforts. The usually reliable, annual distribution finds 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 did not continue for the 2001 survey results (Figure 4.1). Although pelagic fish remained concentrated in the thermocline during 2001, the highest overall densities were found in the deepest survey stratum that was located in the middle of the eastern basin.

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, starting with the 2000 survey year we have recently been able to conduct expanded trawl collections that have corroborated the more limited trawling efforts conducted from 1993 to 1999. Mid-water trawl collections consistently describe the species composition of this pelagic fish community as dominated by rainbow smelt (Table 4.1). During 2001, collections made in the metalimnion and hypolimnion were comprised in excess of 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 in eastern Lake Erie. This definition of YAO rainbow smelt suggests 2001 abundance was slightly higher than 2000. Furthermore, a characteristic alternate year high and low abundance pattern since 1995 has also been apparent in YAO rainbow smelt abundance through our brief time series (Figure 4.2). During the 2001 acoustic survey most of the overall abundance of eastern basin rainbow smelt resource was found in the stratum between 35 and 65 m (Table 4.2).

Finally, a more thorough analysis of acoustic survey results has been planned for several years but annual constraints on staff time have repeatedly postponed undertaking a larger analysis of our entire time series of acoustic data. Initiating this project during 2003 and outside the constraints of annual reporting cycle for the Forage Task Group, may afford an opportunity to complete and report this initiative as a separate paper. The recent purchase of the new signal processing software, *Echoview (Version 3.0, SonarData 2003)* and the completion of a recent research initiative to analyze bias and uncertainty associated with hydroacoustic populations estimates, should significantly advance our program for assessing the pelagic forage fish community.

Acknowledgments

The FTG is grateful to OMNR research vessel captain Gordon Ives, OMNR fisheries Bio-technician Erin Arnold, and NYS DEC staff, Douglas Zeller (research vessel captain), and Brian Beckwith (fish and wildlife technicians) for their annual contributions in support of the eastern basin acoustic survey. The task group would also like to thank Lars Rudstam for his continued guidance and support of the acoustic program.

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.

5.0 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 5.1). Nine key variables, as identified by a panel of lower trophic level experts, were measured to characterize ecosystem change. These variables included profiles of temperature, dissolved oxygen and light (PAR), water transparency (Secchi), 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. In 2001, collections were made at all 20 stations from 4 to 12 times. In 2002, collections were made at all 20 stations from 2 to 12 times. Sampling generally occurred in the first week of the sampling period, but sometimes occurred in the second week.

Results for 2002

Water temperature profiles indicate that west basin station 8 was stratified on June 11 and June 25. All other west basin stations were isothermal throughout the sampling. All central basin stations showed some stratification from end of May through the end of September. Offshore deep stations (16 and 18) in the east basin were stratified from mid June through mid September, and nearshore station 15 was stratified on June 17th and 24th.

Mean bottom dissolved oxygen for each basin was highest in May and declined through the summer (Figure 5.2). West basin dissolved oxygen was lowest at the beginning of July. Central basin dissolved oxygen declined through the summer and started to recover by late September after fall turnover (Figure 5.2). Both west and central basin dissolved oxygen for 2002 were the same as the 1999-2001 means. East basin dissolved oxygen averaged lower than the 1999-2001 mean. Low bottom dissolved oxygen (< 4 mg/L) was measured during the summer at some of the west basin and central basin stations. Measurements under 4 mg/L were recorded in July at stations 4, 6 and 8 in the west basin, one date in August at station 9 in the central basin, and from July through September at station 10 in the central basin.

A gradient in water transparency existed from west to east (Figure 5.3). Secchi depths were shallowest in the west basin, ranging from 0.9 to 4.3 meters, increased to 2.9 to 7.1 m in the central basin, and 4.3 to 8.1 m in the east basin. Lake St. Clair Secchi depths were similar to west basin Secchi depths ranging from 2.2 to 4.0 m. Lake St. Clair, west and central basin Secchi depths for 2002 were similar to the 1999-2001 means, but the east basin Secchi depth was shallower than the 1999-2001 mean.

A west to east gradient also existed for total phosphorus and chlorophyll *a* concentrations (Figures 5.4 and 5.5). Concentrations of both total phosphorus and chlorophyll *a* were generally lowest in the east basin and highest in the west basin. Chlorophyll *a* concentrations were more variable in the west and central basins than in the east basin. Lake St. Clair total phosphorus and chlorophyll *a* concentrations were similar to Lake Erie east basin. West basin 2002 total phosphorus was lower than the 1999-2001 mean, while all the other basins were the same. Central basin Chlorophyll *a* was higher than the 1999-2001 mean, while all the other basins were the same. Phytoplankton samples were collected and archived for all stations.

Zooplankton samples were collected at all stations and benthic samples collected from 14 stations, but analysis of those samples for 2002 is incomplete. Information will be presented in this report when all the data is available. Most zooplankton collections from 2001 are still being analyzed and are not reported this year.

6.0 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 6.1 through 6.5). Round goby abundance data (#/hectare) were obtained from OMNR, ODNR, PFBC, and NYSDEC bottom trawl surveys conducted from August-October of each year. In order to create the figures and keep the axis similar, density estimates within 10 minute grids were averaged and those annual grid means were used to calculate the gridded (kriged) surface for plotting. Arcview software was used to select 20 random locations within each 10 minute grid and applied the mean density to those 20 sites to create the kriging data input files. For years 1994-1997, it was assumed that no goby would have been caught in grids not sampled with trawls. For 1998, it was assumed that grids with no trawling along the north shore of the Central and East Basin had begun to be colonized so the corresponding south shore grid means times 0.5 were applied. The north shore colonization was expanded in 1999 to 0.75 times the south shore grid means. The north shore colonization was further expanded to 100% of the south shore means from 2000 on. A base map showing grids, boundaries and areas trawled is provided in figure 6.1 for reference.

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.

Round goby densities continued to increase in the eastern portions of Lake Erie in 2001 compared to 2000. They have become one of the most abundant species in the index trawl surveys in since their expansion into the eastern basin in 1999. In Lake St. Clair, goby densities have increased dramatically, from 100 per hectare in 2000 to 449 per hectare in 2001. In the central and western areas of the lake, goby densities appear to be stabilizing, having remained the same or declined slightly compared to 2000.

In 2002, Round goby densities tended to decline in most areas of Lake Erie compared to 2001. The only area where goby density increased was in the offshore waters of Long Point Bay. Round goby continue to be a large component of predator diets in all areas of lakes Erie.

7.0 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 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 2001 and 2002. 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.

Species	Trawl Survey	YOY 2002	YOY 2001	YOY 90's Avg.	YOY 80's Avg.	YAO 2002	YAO 2001	YAO 90's Avg.	YAO 80's Avg.
Smelt	ON-DW	148.4	2451.7	475.7	1382.9	5.6	701.5	405.0	969.0
	NY-Fa	1606.6	2727.7	1450.9	NA	117.0	138.3	581.6	NA
	PA-Fa	98.0	34.6	550.8	7058.1	6.5	13.9	378.0	2408.6
Emerald Shiner	ON-DW	9.5	13.1	53.6	20.5	245.0	1455.7	46.2	38.1
	ON-OB	18.9	24.0	113.0	152.3	19.6	21.5	47.7	133.3
	NY-Fa	19.5	366.7	112.4	NA	466.4	333.8	105.4	NA
	Pa-Fa	74.4	0.0	41.0	118.3	105.7	4.6	14.5	45.6
Spottail Shiner	ON-OB	12.2	46.9	696.9	249.3	11.9	6.6	52.6	21.6
	ON-IB	0.0	9.7	113.3	292.6	0.5	1.7	2.0	9.5
	NY-Fa	1.0	40.6	19.9	NA	34.2	7.5	4.0	NA
	PA-Fa	0.0	0.0	4.0	2.0	0.8	0.0	7.9	12.4
Alewife	ON-DW	35.5	76.3	124.7	21.4	NA	NA	NA	NA
	ON-OB	13.4	0.3	60.9	51.4	NA	NA	NA	NA
	NY-Fa	617.6	16.2	52.0	NA	NA	NA	NA	NA
	PA-Fa	0.8	0.0	7.7	16.6	NA	NA	NA	NA
Gizzard Shad	ON-DW	3.2	14.7	5.1	15.3	NA	NA	NA	NA
	ON-OB	1.5	5.8	9.6	24.2	NA	NA	NA	NA
	NY-Fa	5.5	39.7	4.2	NA	NA	NA	NA	NA
	PA-Fa	0.8	0.0	0.9	74.3	NA	NA	NA	NA
White Perch	ON-DW	0.0	6.0	2.1	5.6	NA	NA	NA	NA
	ON-OB	0.0	3.9	14.1	28.7	NA	NA	NA	NA
	NY-Fa	6.2	19.3	29.4	NA	NA	NA	NA	NA
	PA-Fa	0.0	677.4	101.1	955.0	NA	NA	NA	NA
Round Goby[a]	ON-DW	123.4	66.1	0.0	0.0	NA	NA	NA	NA
	ON-OB	96.4	128.6	0.1	0.0	NA	NA	NA	NA
	NY-Fa	48.0	111.4	0.0	0.0	NA	NA	NA	NA
	PA-Fa	75.8	383.9	28.3	0.0	60.1	191.5	3.9	0.0

"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 1990-2002.

		Year													
Species	**Agency**	**1990 [a]**	**1991 [a]**	**1992 [a]**	**1993 [a]**	**1994 [a]**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**Mean**
Alewife	OH	0.3	5.1	23.1	0.0	8.7	12.2	8.5	18.1	4.7	15.9	34.9	22.2	29.4	14.1
	PA	0.0	-	174.3	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	15.9
Gizzard	OH	38.1	4.6	9.5	3.0	17.0	1.2	92.7	13.0	33.9	45.2	64.4	25.0	16.3	28.0
Shad	PA	40.9	-	0.0	-	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
Rainbow	OH	1008.9	15.1	612.4	20.7	1045.0	843.7	1366.1	470.0	678.9	207.2	579.4	1.1	225.5	544.2
Smelt	PA	1128.2	-	8205.0	-	952.9	106.7	5422.1	10.3	29.9	1.8	15.3	377.4	152.9	1491.4
Emerald	OH	106.9	59.8	42.7	2.6	14.9	27.5	38.3	66.0	1822.6	365.7	291.8	22.5	9.5	220.8
Shiner	PA	366.5	-	33.6	-	0.0	53.6	3.5	0.0	5.8	0.0	0.0	8.5	38.1	46.3
Spottail	OH	0.7	0.1	0.4	5.5	8.4	1.0	15.1	5.8	1.3	4.1	0.2	2.5	0.5	3.5
Shiner	PA	0.0	-	0.0	-	0.0	19.9	0.0	0.0	0.0	0.8	0.0	0.0	0.0	1.9
Trout-	OH	10.1	4.7	46.2	5.0	0.0	6.6	11.2	1.1	0.8	3.7	0.5	0.7	0.4	7.0
Perch	PA	0.0	-	214.1	-	1.1	24.9	7.1	0.0	23.1	10.0	23.0	7.8	45.7	32.4
White	OH	1981.7	1378.3	192.8	86.6	261.3	35.9	330.7	107.5	69.7	155.4	227.4	390.3	98.6	408.9
Perch	PA	1527.6	-	887.5	-	76.3	136.0	331.5	0.0	0.0	8.5	75.9	26.6	80.7	286.4
White	OH	38.4	10.9	0.5	33.1	122.6	16.9	60.3	19.9	40.7	105.5	20.7	89.4	16.0	44.2
Bass	PA	16.6	-	0.0	-	6.6	4.4	0.0	0.0	0.0	0.0	96.4	12.1	0.0	12.4
Yellow	OH	35.4	6.5	34.2	12.7	48.2	6.2	112.9	6.2	55.7	39.9	9.3	73.5	2.9	34.1
Perch	PA	8.6	-	124.8	-	567.4	52.0	354.1	0.0	13.7	7.2	15.7	388.4	11.9	140.3
Round	OH	-	-	-	-	3.0	29.3	35.1	98.7	171.6	128.9	81.3	41.4	44.8	70.5
Goby	PA	-	-	-	-	-	-	0.4	1.5	743.6	1114.4	781.1	1577.8	289.4	644.0

[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 1990-2002.

Species	Agency	Year													Mean
		1990 [a]	1991 [a]	1992 [a]	1993 [a]	1994 [a]	1995	1996	1997	1998	1999	2000	2001	2002	
Alewife	OH	0.0	0.1	0.1	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.7	0.0	1.8	0.2
	PA	0.0	-	61.1	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	5.7
Gizzard Shad	OH	0.7	0.3	0.3	0.7	0.0	1.8	0.0	0.1	0.1	0.5	2.6	0.1	1.3	0.7
	PA	0.6	-	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rainbow Smelt	OH	17.4	91.6	24.8	95.6	33.0	157.5	80.2	346.4	79.0	922.4	125.3	35.8	97.0	162.0
	PA	43.1	-	540.6	-	4.4	506.0	29.9	25.6	1.34	0.0	75.8	0.0	6.2	112.0
Emerald Shiner	OH	54.3	70.6	2.9	5.5	4.3	37.4	15.2	87.5	739.4	465.2	440.6	39.3	150.4	162.5
	PA	2.8	-	240.7	-	0.6	17.7	0.0	0.0	0.0	0.0	0.0	0.0	107.4	32.9
Spottail Shiner	OH	1.5	0.7	0.7	0.3	5.4	9.0	10.0	9.0	13.5	6.0	7.2	1.8	5.0	5.4
	PA	18.2	-	0.0	-	0.0	17.7	0.0	0.0	0.4	0.0	0.0	0.0	2.2	3.5
Trout-Perch	OH	7.0	11.8	16.8	9.6	10.4	13.8	10.3	13.8	14.5	8.0	12.4	2.7	14.3	11.2
	PA	64.2	-	132.7	-	7.2	53.1	0.0	8.9	1.0	0.9	11.5	0.6	81.2	32.8
White Perch	OH	79.8	222.2	140.7	1.4	0.8	22.5	13.6	39.6	2.3	30.1	65.3	11.3	160.4	60.8
	PA	42.0	-	61.5	-	0.0	1.7	1.8	0.0	0.0	1.9	0.6	2.4	38.5	13.6
White Bass	OH	0.1	0.0	0.4	0.0	0.0	2.9	0.3	14.1	0.3	3.2	17.6	1.7	5.7	3.6
	PA	5.0	-	0.4	-	2.8	0.0	0.0	0.0	0.0	6.0	1.0	57.6	0.4	6.7
Yellow Perch	OH	19.3	14.5	20.8	21.6	6.3	47.4	29.5	63.2	34.5	49.5	63.7	23.5	49.0	34.1
	PA	50.9	-	57.5	-	2.2	191.9	12.4	14.6	2.6	7.9	3.9	41.3	37.5	38.4
Round Goby	OH	-	-	-	-	2.7	51.5	142.4	331.8	150.6	98.9	81.0	88.3	44.0	110.1
	PA	-	-	-	-	-	-	0	0	113.1	55.3	126.5	55.2	238.3	84.1

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

Table 4.1. 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 – 2001.

Thermal Stratum		***1996***	***1997***	***1998***	***1999***	***2000***	***2001***	***Total 1996 - 2001***
Epilimnion	# of tows	4	4	6	2	10	9	35
	# of yao fish	1,867	901	15	508	2,627	3,296	9,214
	% yao smelt	98.5%	80.0%	73.3%	99.6%	85.5%	99.8%	93.47%
Metalimnion	# of tows	4	4	3	4	9	4	28
	# of yao fish	3,880	4,847	2,829	2,151	9,579	9,674	32,960
	% yao smelt	97.4%	97.9%	99.6%	99.3%	99.8%	100.0%	99.3%
Hypolimnion	# of tows	1	2	1	2	7	6	19
	# of yao fish	107	3,796	1,428	6,529	14,920	17,855	44,635
	% yao smelt	97.2%	>99.9%	99.7%	>99.9%	>99.9%	>99.9%	>99.9%

Table 4.2. 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, 2001. Confidence limits (95%) are the percent of the total abundance estimate.

Depth Strata	**Total Numeric Abundance**	**(95 % Conf. Lmt. as % of mean)**
18 to 25 m	107,253,686	39.21%
25 to 35 m	337,033,836	17.03%
> 35 m	661,981,215	13.88%
TOTAL	1,106,268,737	6.43%

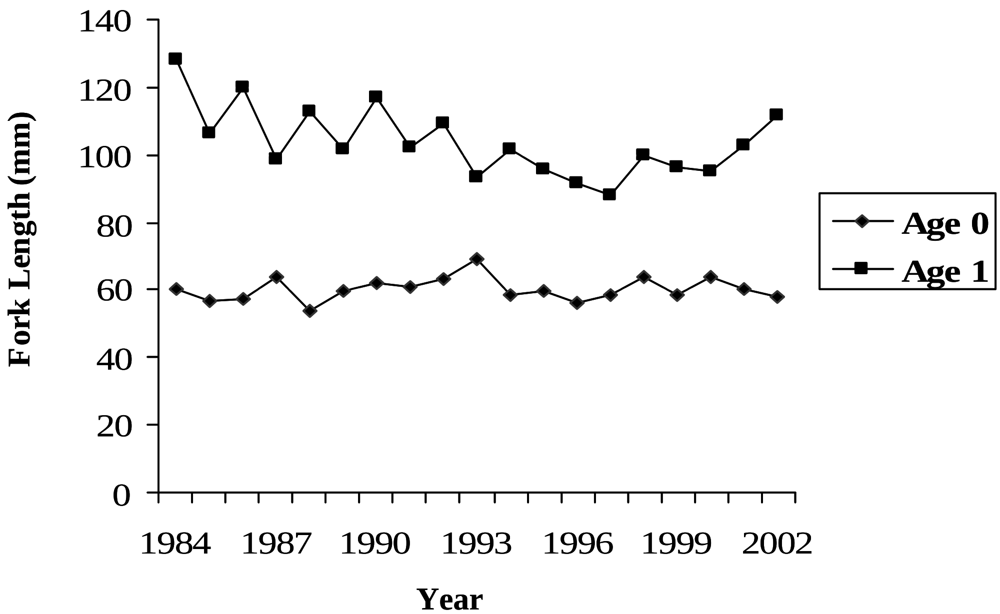


Figure 2.1 Mean fork length age 0 and age1 rainbow smelt from OMNR index trawl surveys in Long Point Bay, Lake Erie, October 1984 to 2002 .

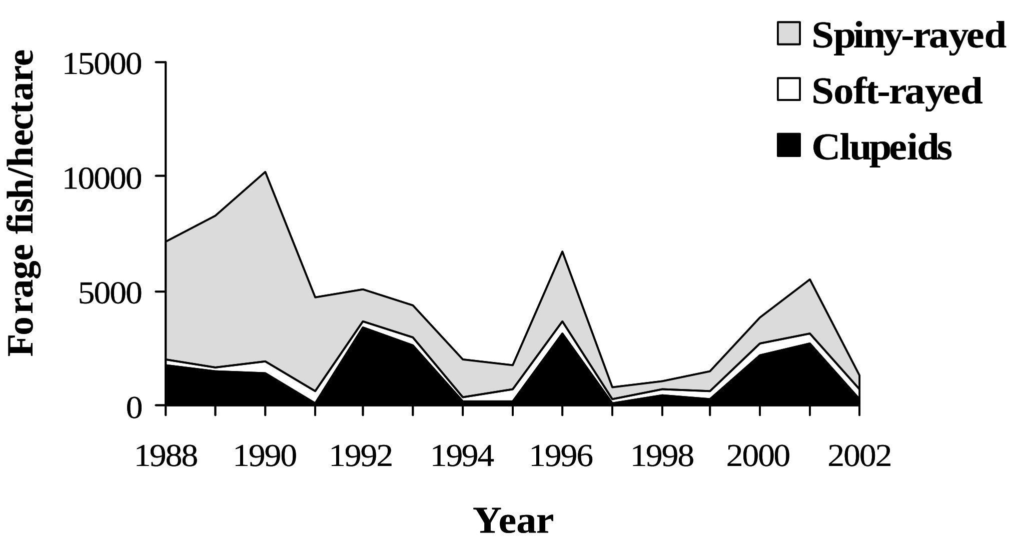


Figure 2.2. Mean abundance (#/hectare) of functional prey fish groups in Ontario waters of the western basin, Lake Erie, 1988-2002.

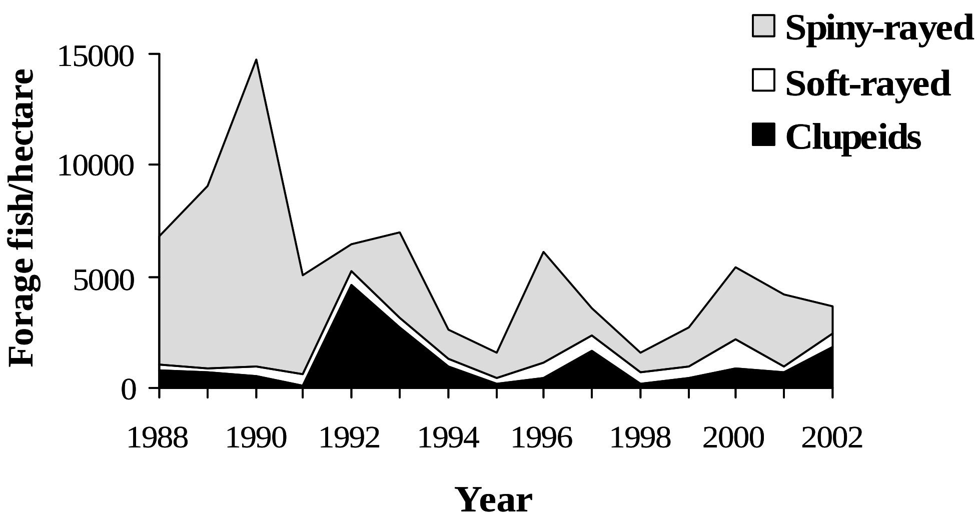


Figure 2.3. Mean abundance (#/hectare) of functional prey fish groups in Ohio waters of the western basin, Lake Erie, 1988-2002.

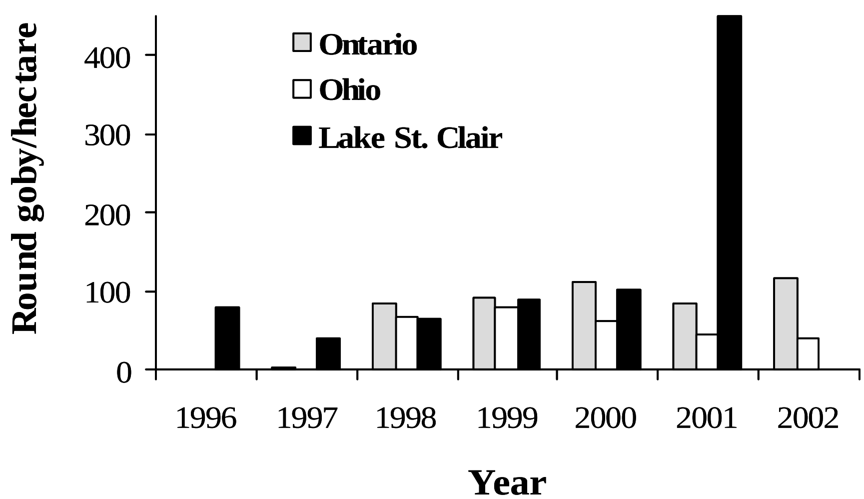


Figure 2.4. Mean abundance (#/hectare) of round gobies from August agency trawls in Lake St. Clair and the western basin of Lake Erie, 1996-2002.

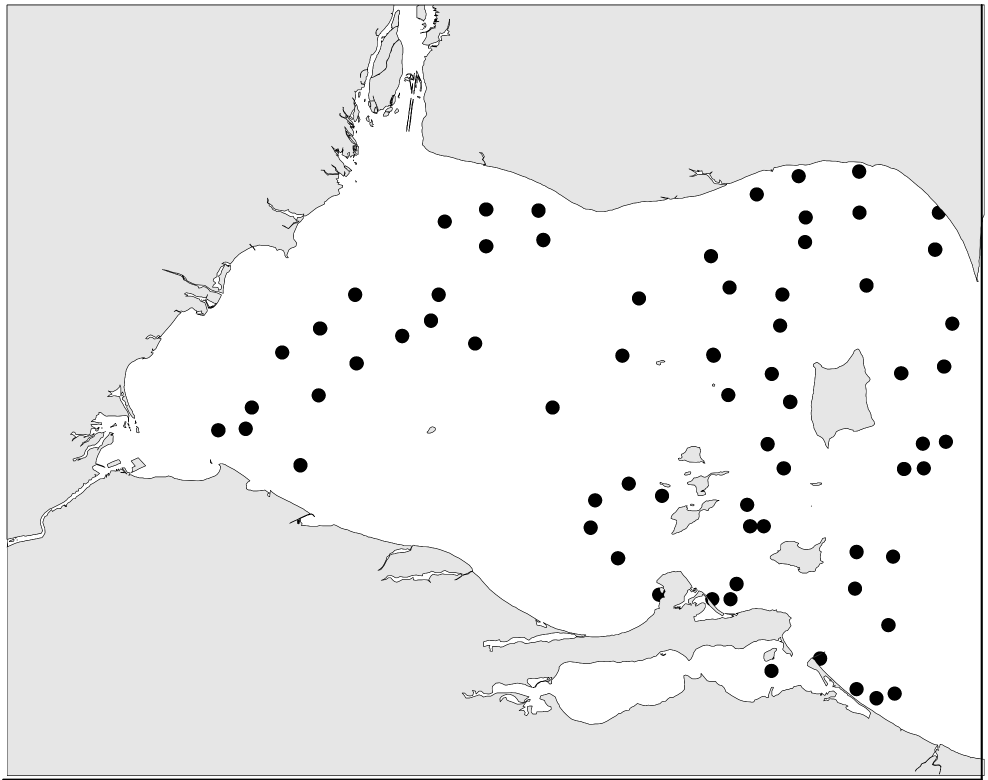


Figure 3.1. Trawl locations for western basin interagency trawl survey, August, 2002.

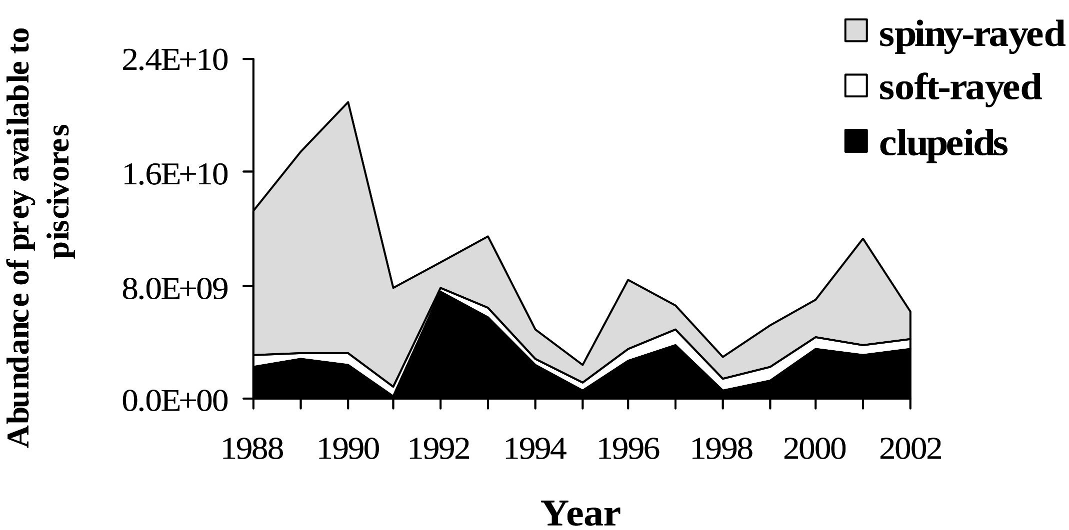


Figure 3.2. Estimated absolute abundance of prey fish by functional category in waters of the western basin, Lake Erie, 1988-2002.

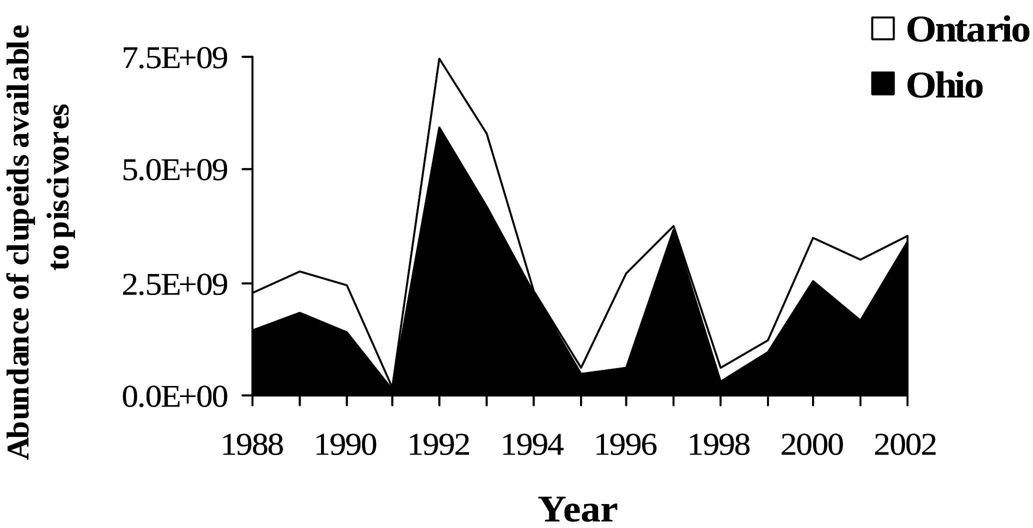


Figure 3.3. Estimated absolute abundance of clupeids in Ohio and Ontario waters of the western basin, Lake Erie, 1988-2002.

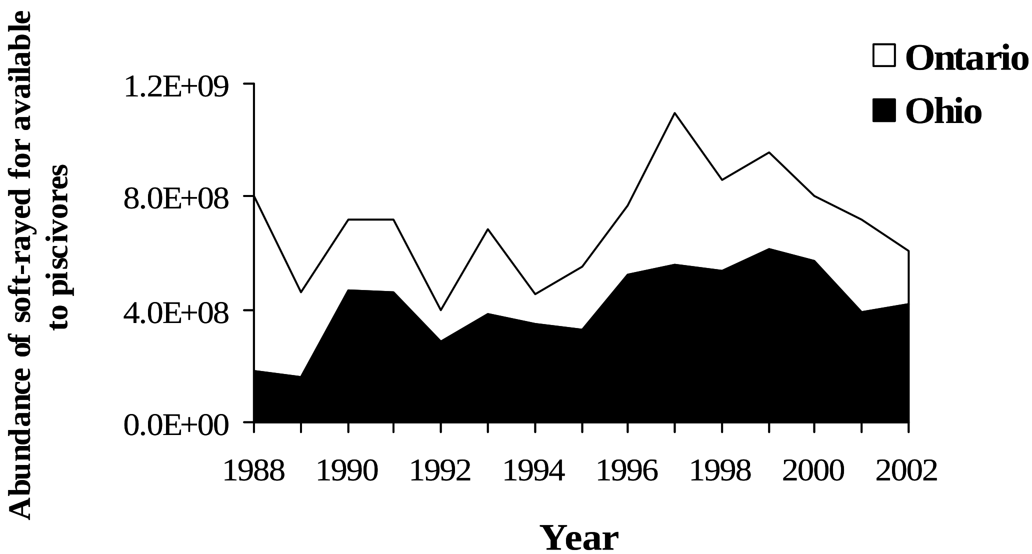


Figure 3.4. Estimated absolute abundance soft-rayed forage in Ohio and Ontario waters of the western basin, Lake Erie, 1988-2002.

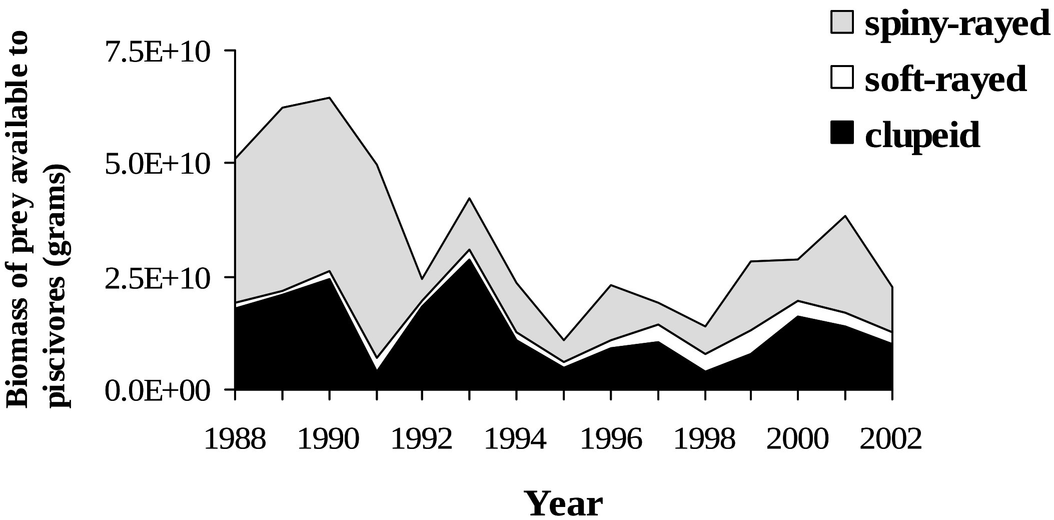


Figure 3.5. Estimated absolute biomass of prey by functional category in waters of the western basin, Lake Erie, 1988-2002.

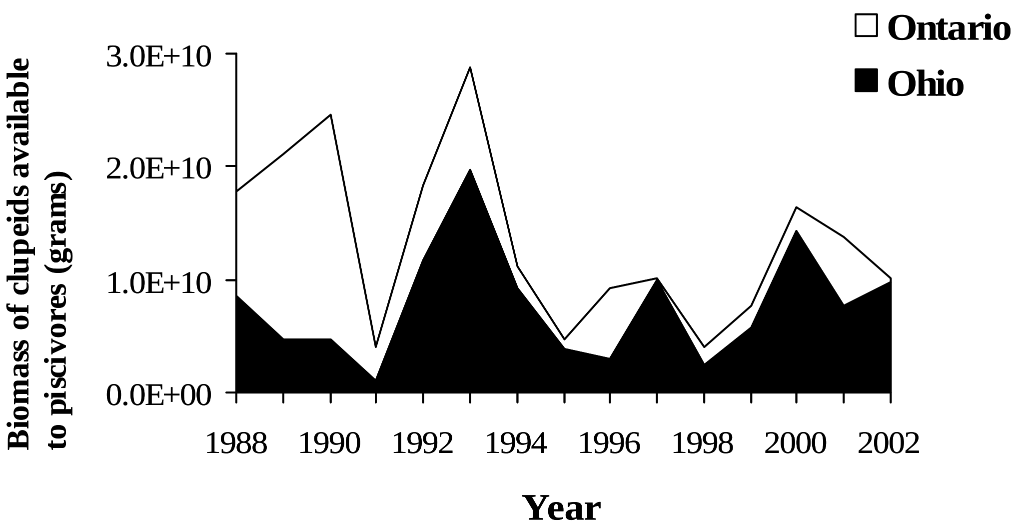


Figure 3.6. Estimated absolute biomass of clupeids in Ohio and Ontario waters of the western basin, Lake Erie, 1988-2002.

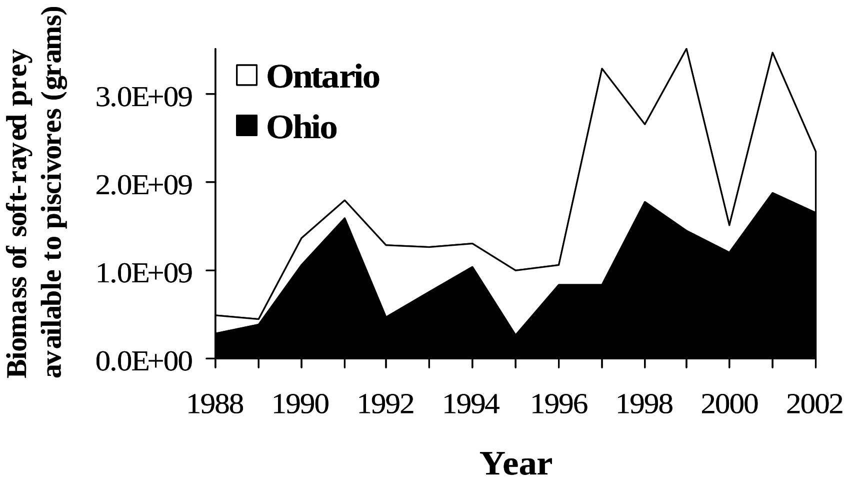


Figure 3.7. Estimated absolute biomass of soft-rayed prey in Ohio and Ontario waters of the western basin, Lake Erie, 1988-2002.

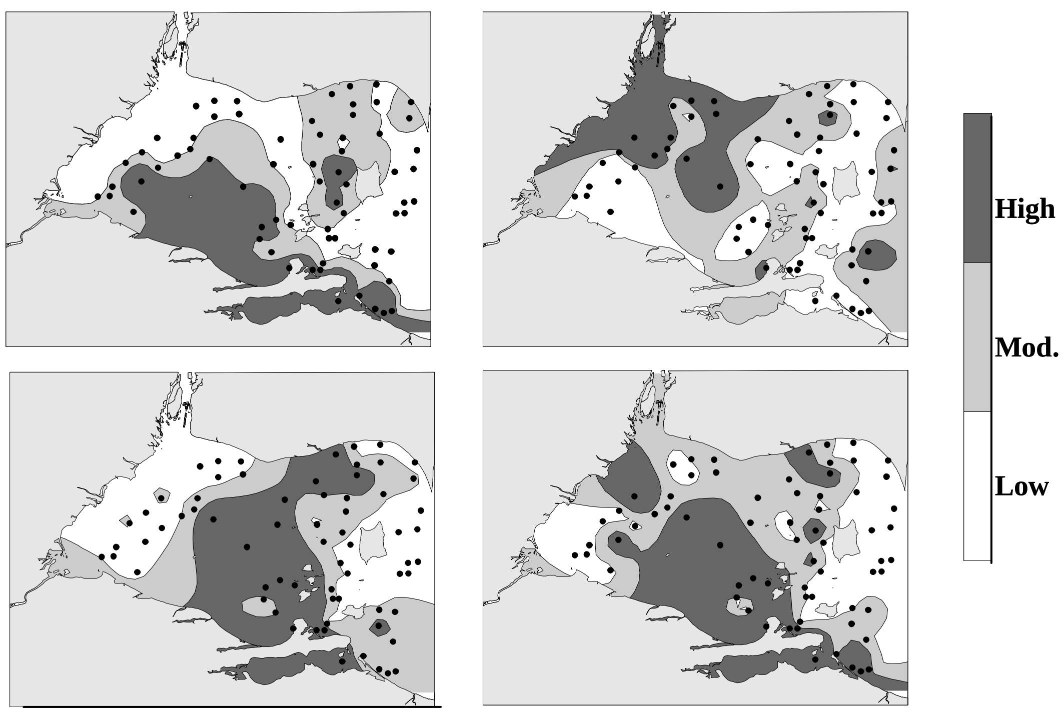


Figure 3.8. Spatial distribution of clupeids (a), soft-rayed forage (b), spiny-rayed forage (c), and total forage (d) in western basin of Lake Erie, August, 2002. Contour levels vary for each functional prey category.

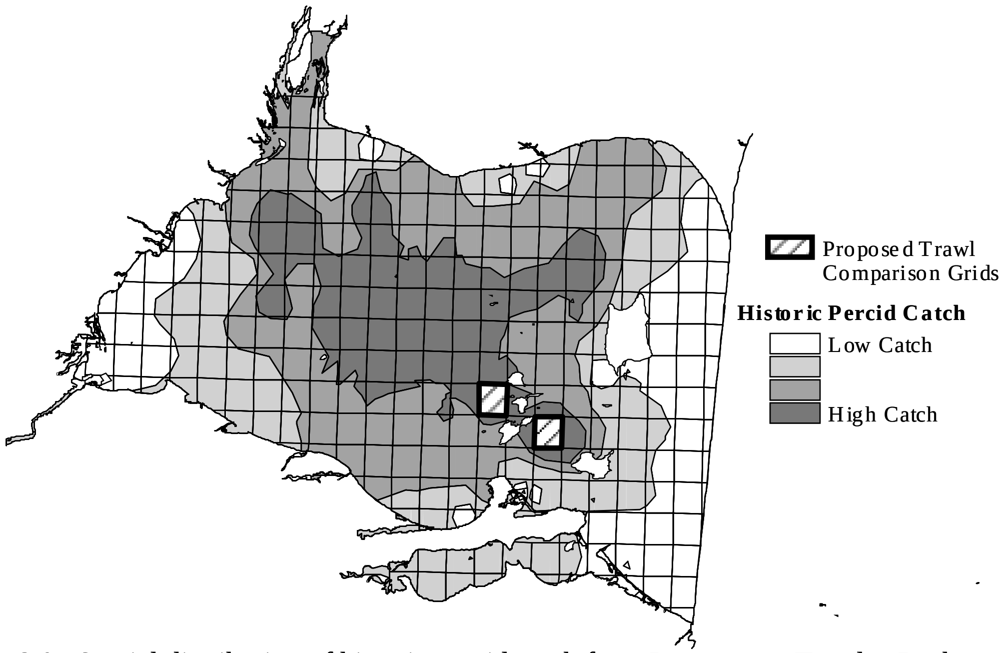


Figure 3.9. Spatial distribution of historic percid catch from Interagency Trawls. Darker areas represent areas with higher historic catch. Cross-hatched grids represent proposed comparative trawling sample locations

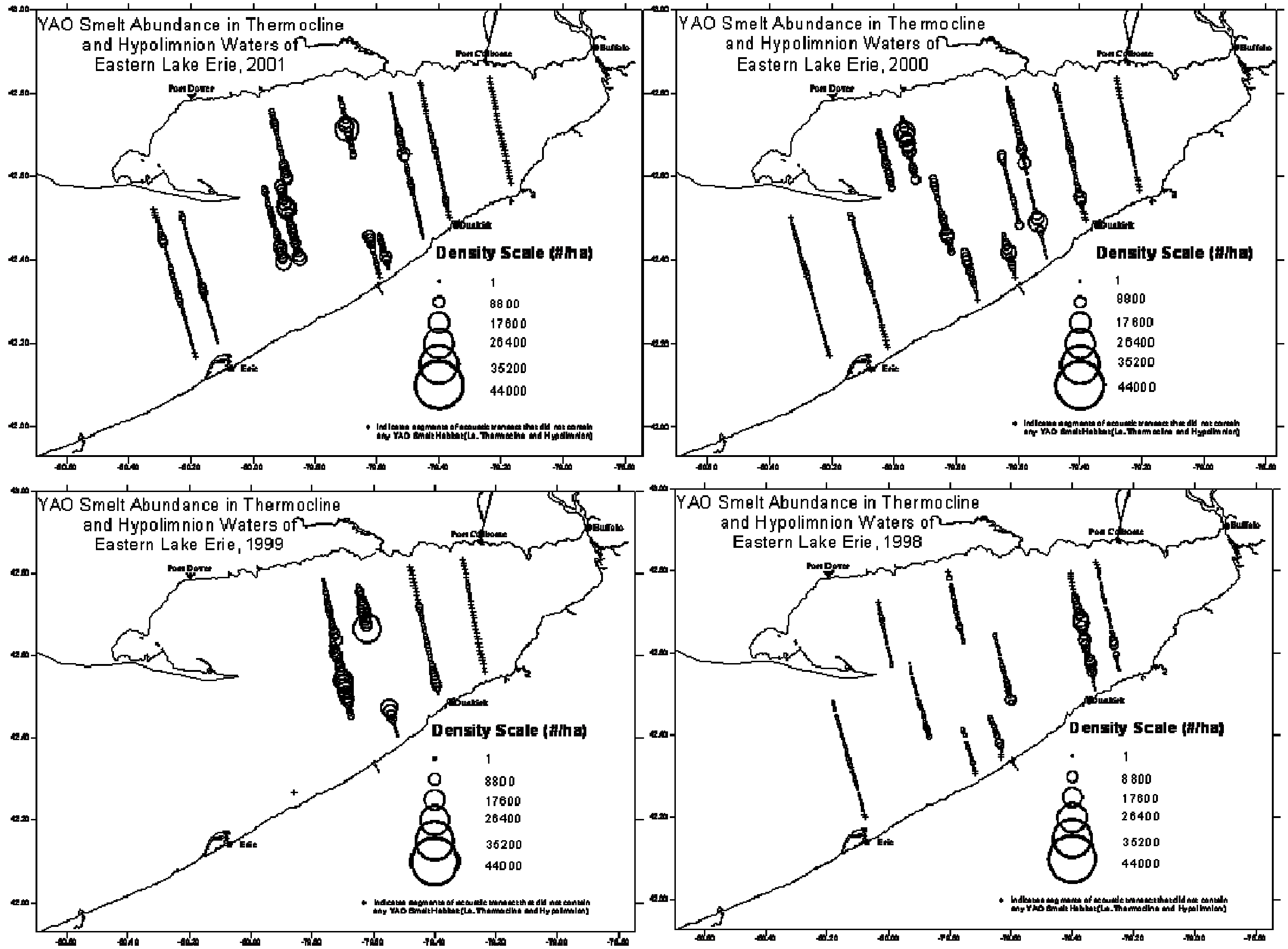
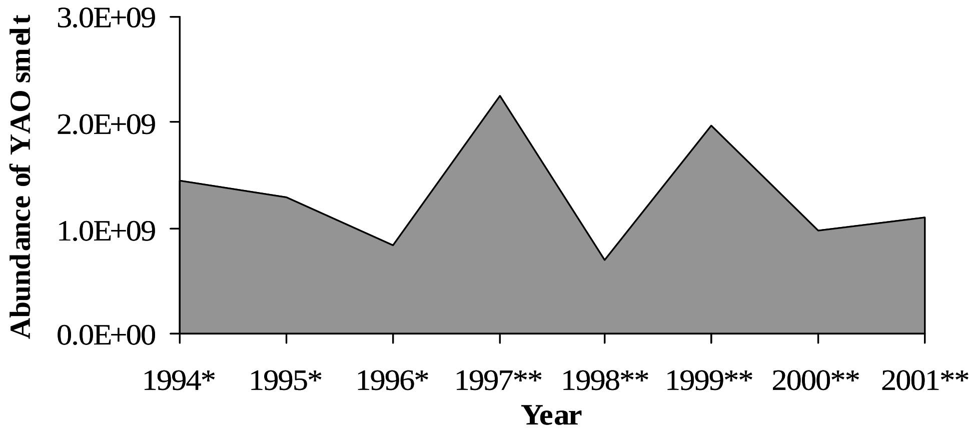


Figure 4.1 Sampling locations and relative density of pelagic, adult forage-sized fish during July, 1998 to 2001 fisheries acoustic surveys.



* - 1994 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 4.2 Eastern basin, July index of yearling-and-older pelagic forage fish estimate obtained from annual summer acoustic surveys.

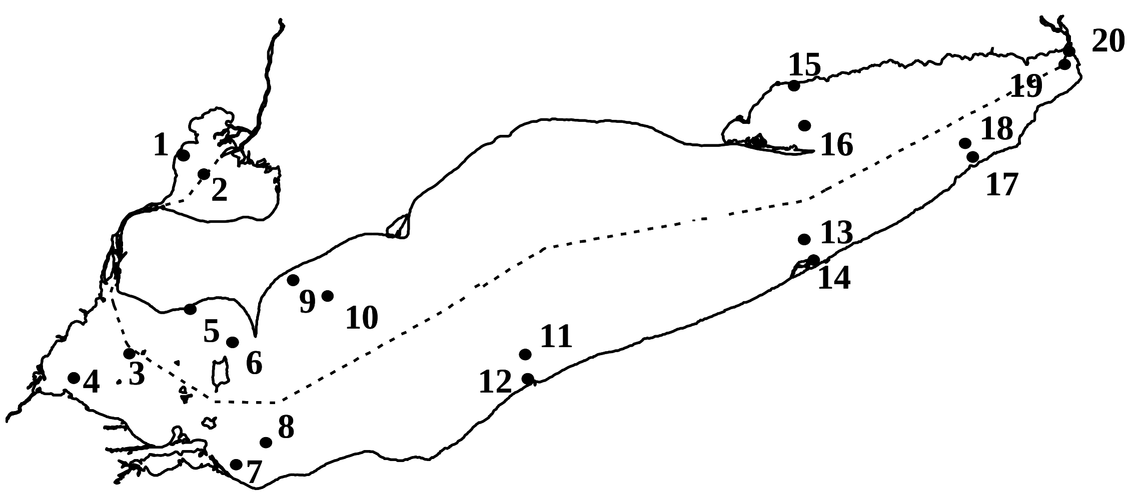


Figure 5.1. Lower Trophic Level sample stations in Lakes Erie and St. Clair, 2002.

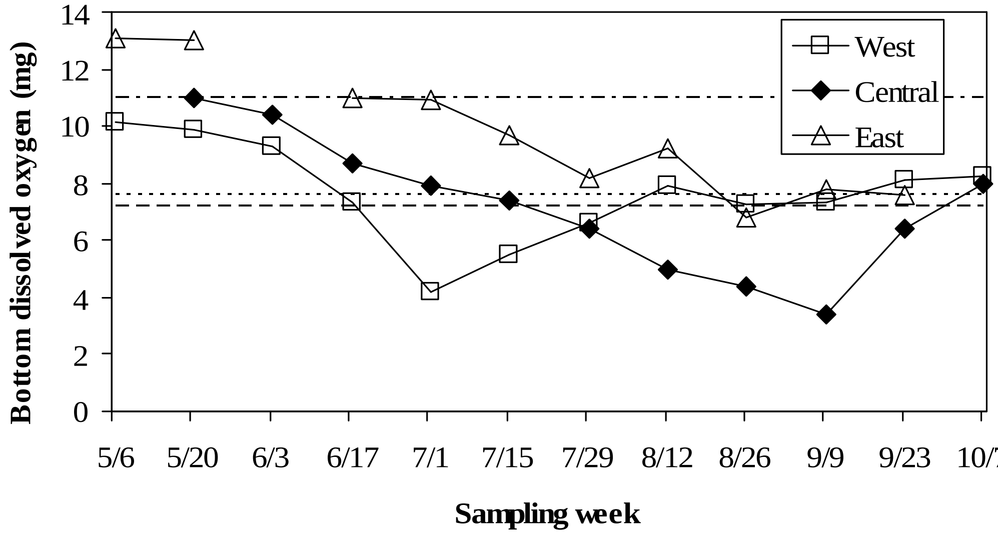


Figure 5.2 Mean Bottom dissolved oxygen (mg/L) for each basin of Lake Erie by sampling period, 2002. Values are means of measurements recorded within each basin. Western basin sites 3-8, central basin sites are 9-14, and eastern basin sites are 15-20. Dashed lines represent 1999-2001 annual mean for each basin (western 7.6 mg/L, central 7.2 mg/L, eastern 11.0 mg/L).

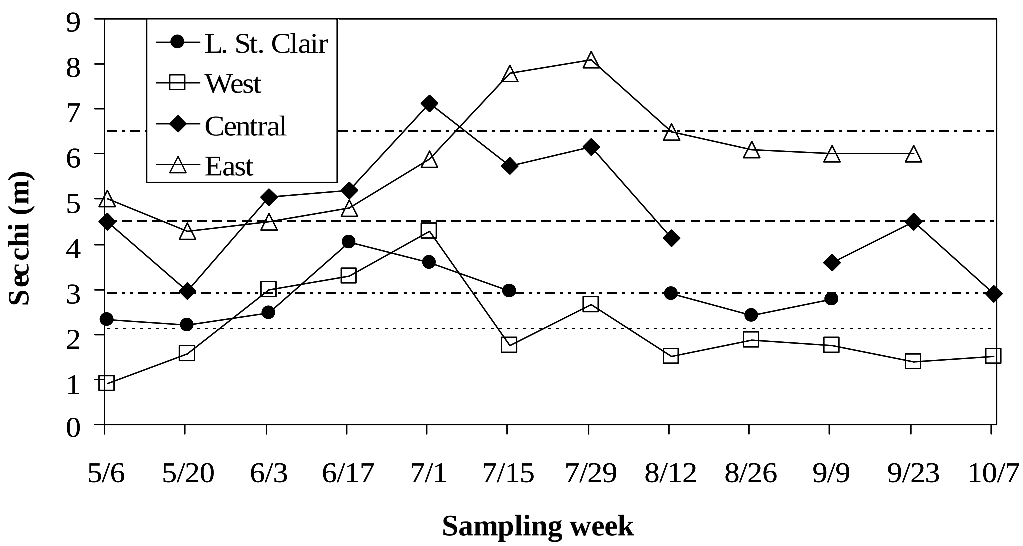


Figure 5.3 Mean Secchi depths (m) for each basin of Lake Erie and Lake St. Clair by sampling period, 2002. Values are means of measurements recorded within each basin (sites 1-2 = L. St. Clair, sites 3-8 = west basin, sites 9-14 = central basin, and sites 15-20 = east basin). Dashed and dotted lines represent 1999-2001 annual mean for each basin (Lake St. Clair, dash-dot-dot line at 2.9 m; west, dotted line at 2.1 m; central, dashed line at 4.5 m; east, dash-dot line at 6.5 m).

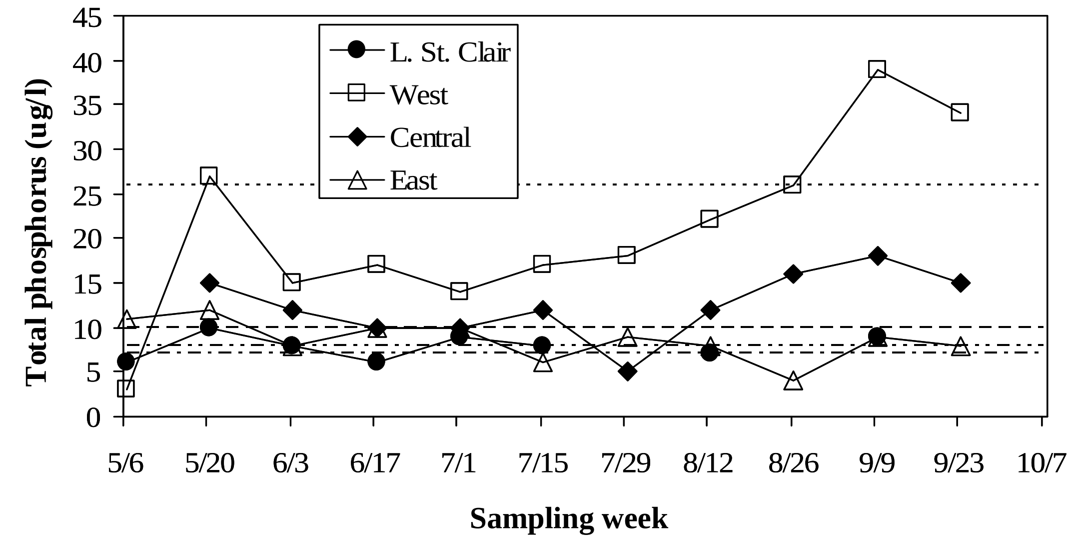


Figure 5.4 Mean total phosphorus (µg/L) for each basin of Lake Erie and Lake St. Clair by sampling period, 2002. Values are means of measurements recorded within each basin (sites 1-2 = L. St. Clair, sites 3-8 = west basin, sites 9-14 = central basin, and sites 15-20 = east basin). Dashed and dotted lines represent 1999-2001 annual mean for each basin (L. St. Clair, dash-dot-dot line at 8 µg/L; west, dotted line at 26 µg/L; central, dashed line at 10 µg/L; east, dash-dot line at 7 µg/L).

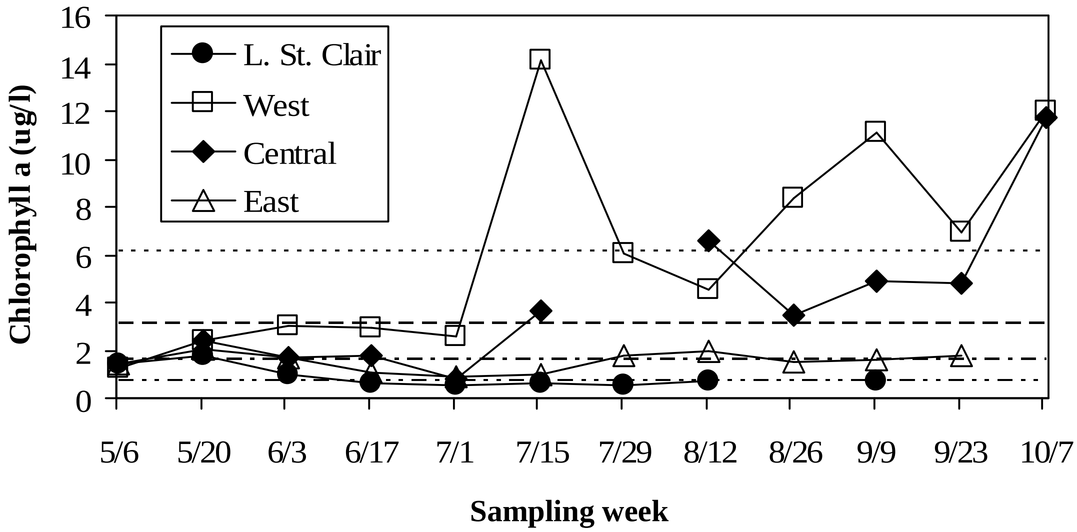


Figure 5.5 Mean chlorophyll a (µg/L) for each basin of Lake Erie and Lake St. Clair by sampling period, 2002. Values are means of measurements recorded within each basin (sites1-2 = L. St. Clair, sites 3-8 = west basin, sites 9-14 = central basin, and sites 15-20 = east basin). Dashed and dotted lines represent 1999-2001 annual mean for each basin (L. St. Clair, dash-dot-dot at 0.7 µg/L; west, dotted at 6.2 µg/L; central, dashed at 3.1 µg/L; east, dash-dot at 1.6 µg/L).

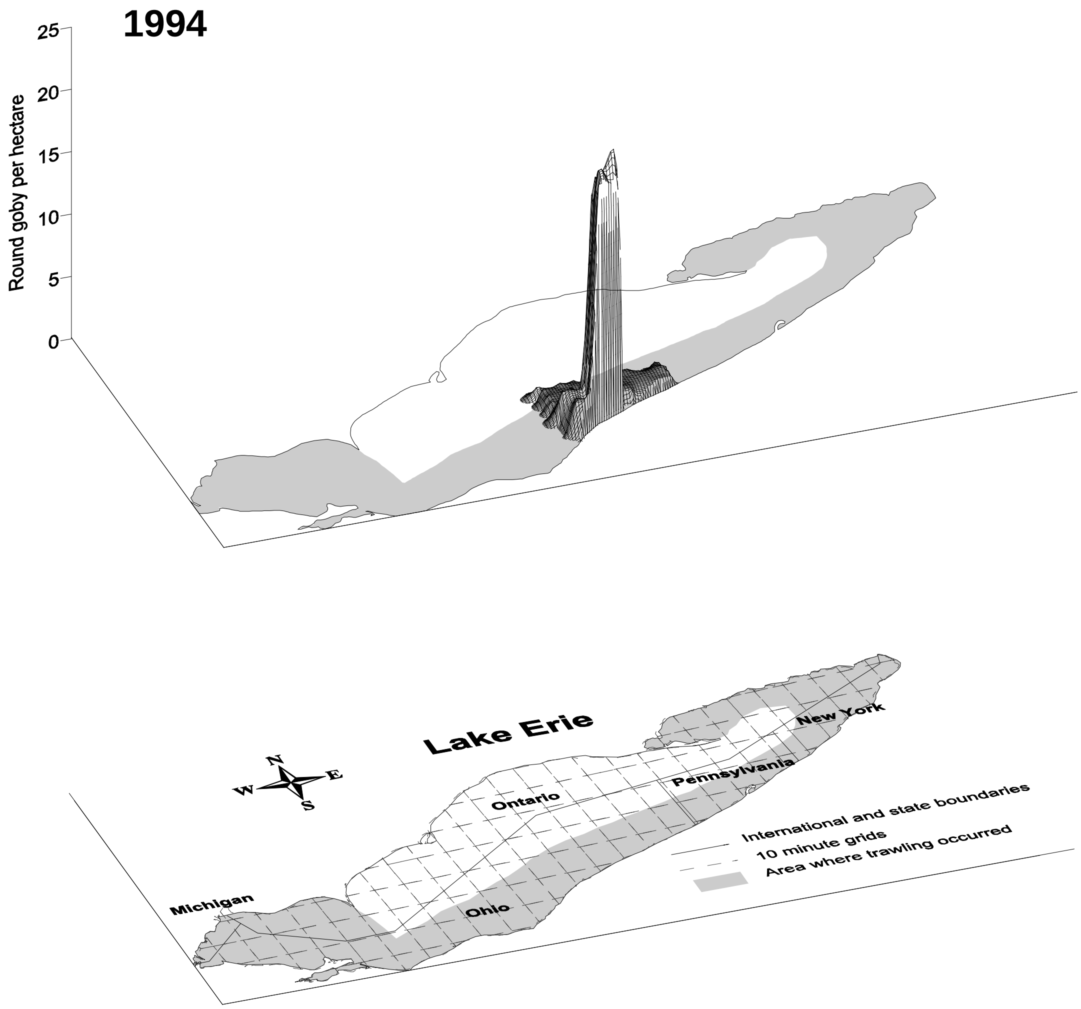


Figure 6.1 Two dimensional base map (lower) and three dimensional map of round goby distribution in Lake Erie as density per hectare (upper) during 1994 estimated from bottom trawl catches. The base map shows state and provincial boundaries, the ten minute grid system used for trawl data summarization, and the area of the lake sampled with bottom trawls (shaded gray). The 1994 goby distribution map was extrapolated from individual bottom trawl catches averaged within 10 minute grids using SURFER© software and a kriging algorithm.

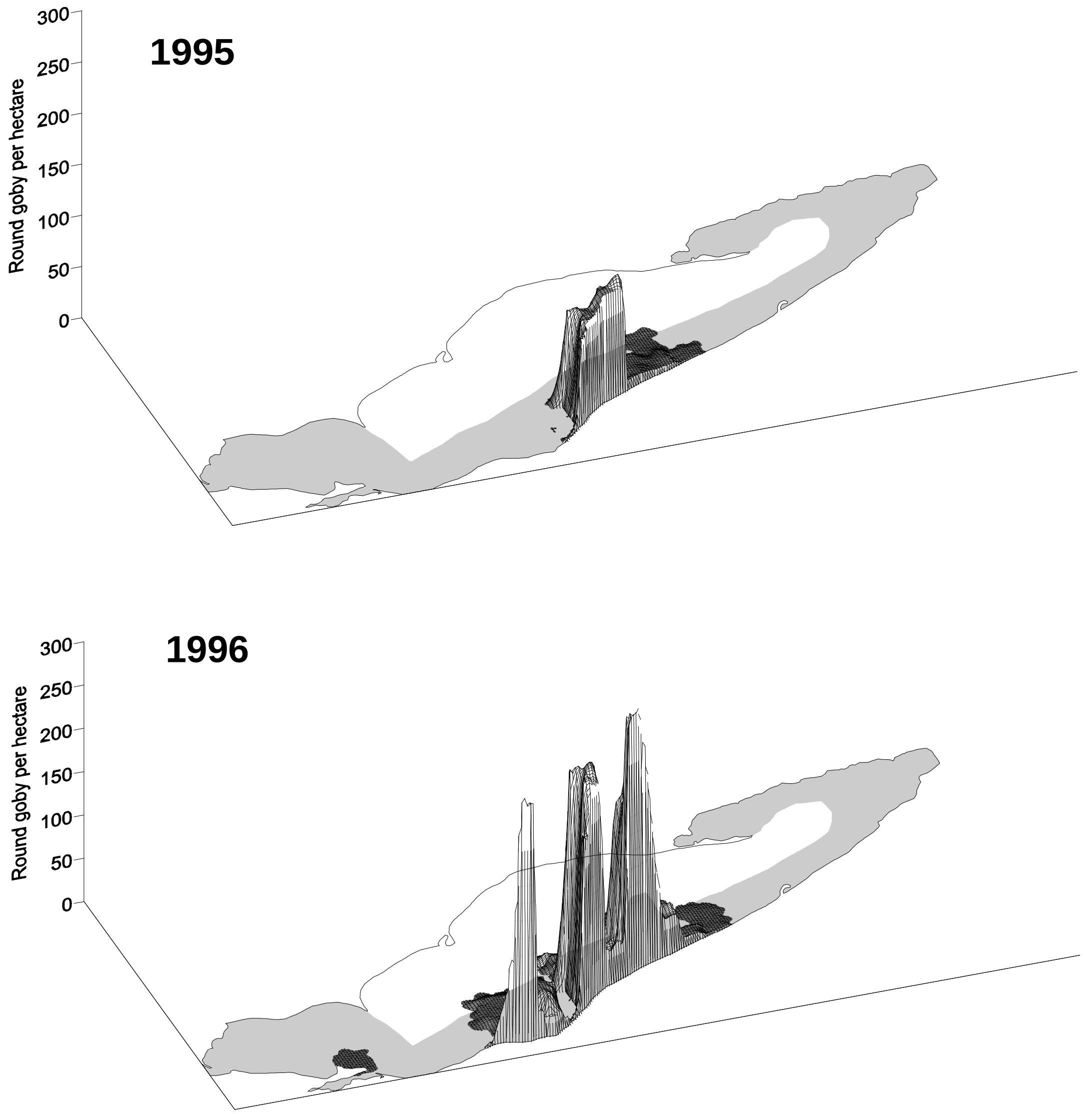


Figure 6.2 Three dimensional maps of round goby distribution in Lake Erie as density per hectare during 1995 (upper) and 1996 (lower) estimated from bottom trawl catches. The goby distribution maps were extrapolated from individual bottom trawl catches averaged within 10 minute grids using SURFER© software and a kriging algorithm.

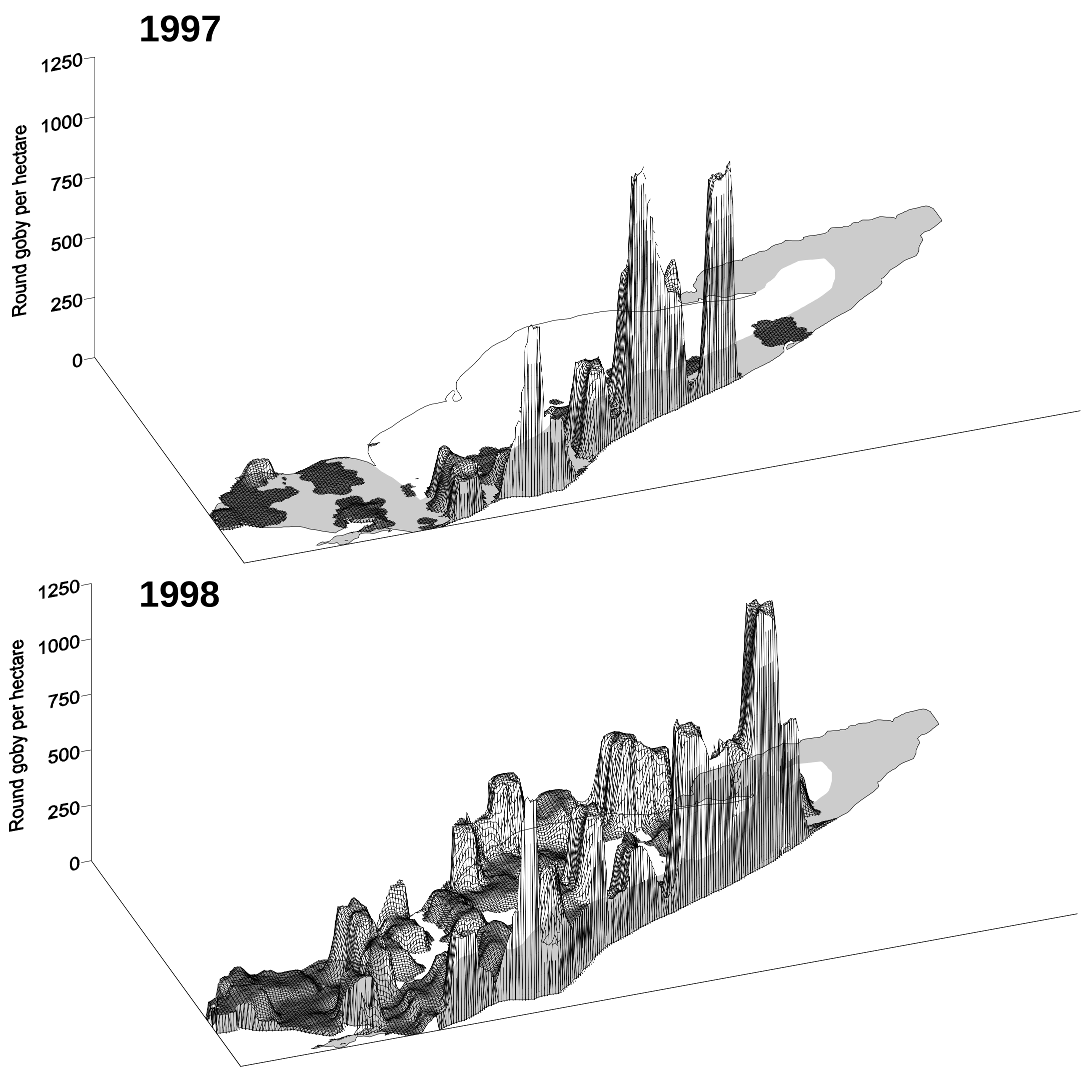


Figure 6.3 Three dimensional maps of round goby distribution in Lake Erie as density per hectare during 1997 (upper) and 1998 (lower) estimated from bottom trawl catches. The goby distribution map for 1997 was extrapolated from individual bottom trawl catches averaged within 10 minute grids using SURFER© software and a kriging algorithm. The 1998 map was generated by assuming one half of the average density estimates from adjacent ten minute grids containing trawl data represented 10 minute grids with no trawl data. There was ample evidence from ancillary observations that round goby had begun colonizing Ontario waters of the Central Basin.

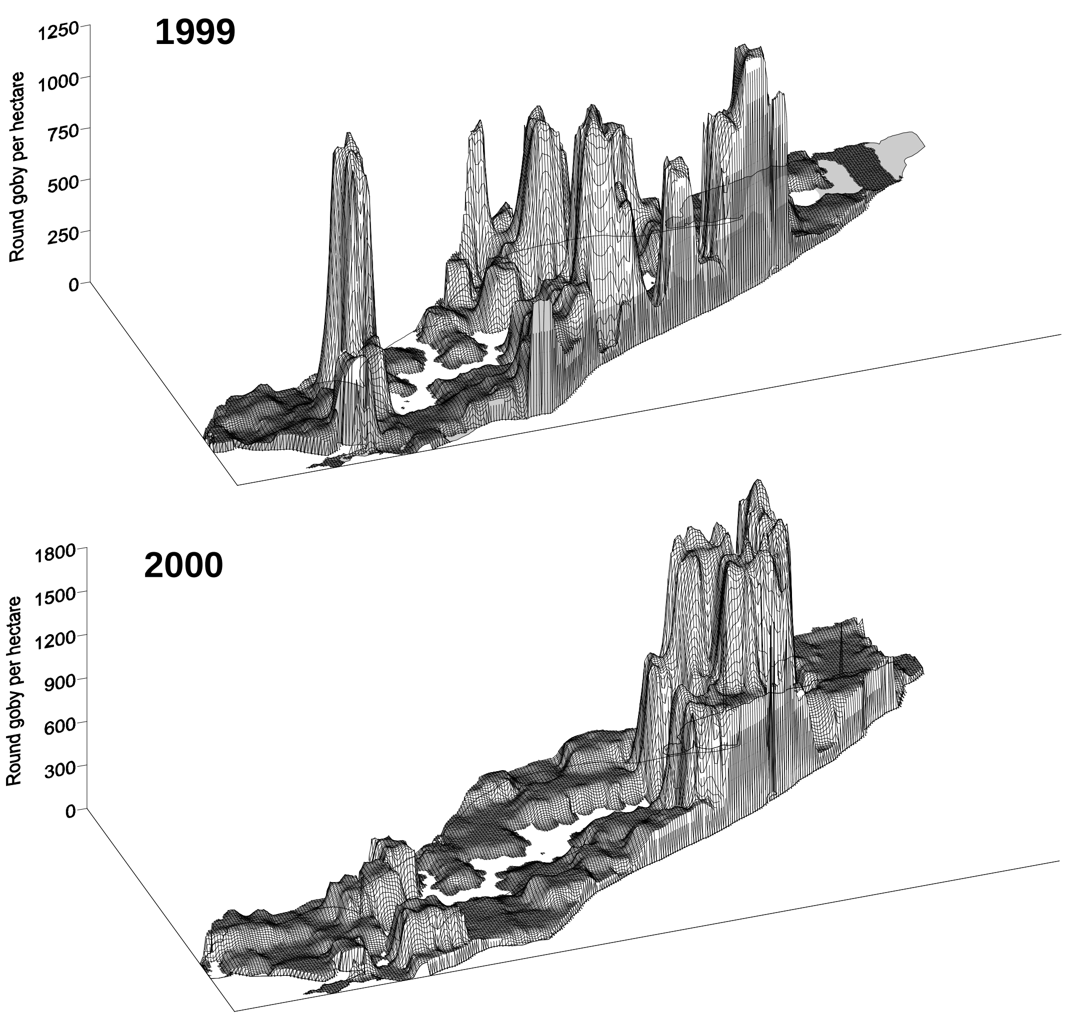


Figure 6.4 Three dimensional maps of round goby distribution in Lake Erie as density per hectare during 1999 (upper) and 2000 (lower) estimated from bottom trawl catches. The goby distribution maps were extrapolated from individual bottom trawl catches averaged within 10 minute grids using SURFER© software and a kriging algorithm. The 1999 map was generated by assuming three quarters of the average density estimates from adjacent ten minute grids containing trawl data represented 10 minute grids with no trawl data. The 2000 map was generated by assuming average density estimates from adjacent ten minute grids containing trawl data represented 10 minute grids with no trawl data. There was ample evidence from ancillary observations that round goby had steadily colonized Ontario waters of the Central Basin.

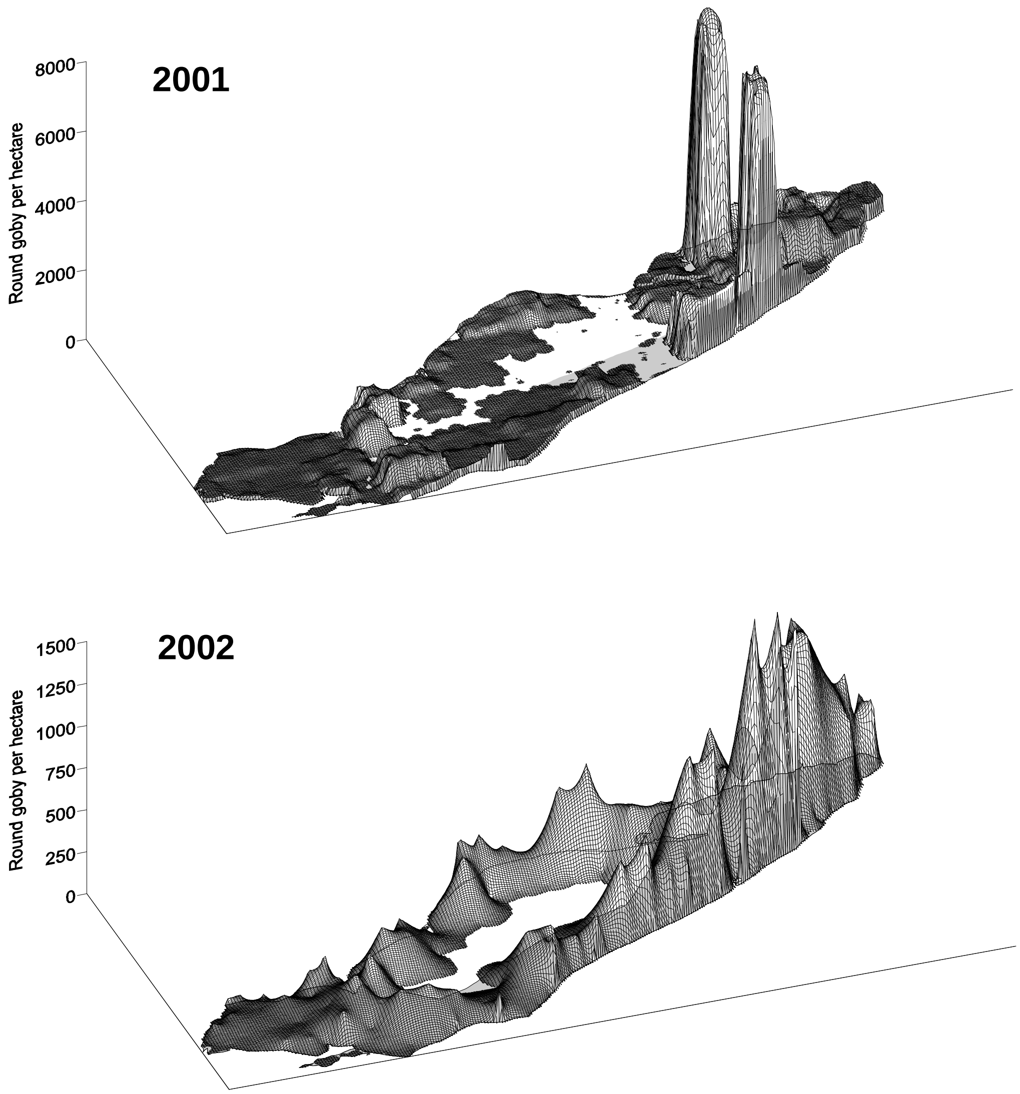


Figure 6.5 Three dimensional maps of round goby distribution in Lake Erie as density per hectare during 2001 (upper) and 2002 (lower) estimated from bottom trawl catches. The goby distribution maps were extrapolated from individual bottom trawl catches averaged within 10 minute grids using SURFER© software and a kriging algorithm. The maps were generated by assuming average density estimates from adjacent ten minute grids containing trawl data represented 10 minute grids with no trawl data. There was ample evidence from ancillary observations that round goby had steadily colonized Ontario waters of the Central Basin.