Report of the
Lake Erie
Forage Task Group

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Presented to:

Standing Technical Committee
Lake Erie Committee
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1.0 Charges to the Forage Task Group in 2003-2004

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. In Eastern Lake Erie continue the fisheries acoustics assessment of the pelagic forage fish community, incorporating new methods in survey design and analysis as necessary to refine this program. Fisheries acoustic surveys should also be explored in other portions of Lake Erie to address un-met needs for assessment of the pelagic forage fish community.

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

2.0 Forage Task Group Bullet Statements

2.1 2003 Forage Task Group Synopsis

General Patterns

- Very strong percid and smelt year-classes: emerald shiners and white perch increased.
- Very poor alewife recruitment.
- Round goby CPUE still increasing in the east; round gobies continue to increase in diets.
- Predator diets remain dominated by smelt in the east; decreasing reliance on clupeids in the rest of lake.
- Age-0 growth generally good.
- Water temperature decreased; chlorophyll a decreased.

Eastern Basin

- Strongest age-0 smelt year-class in 20 years; age-1+ smelt increased.
- Emerald shiners, white perch, round goby, and trout-perch increased. Alewife decreased.
- Predator diets remain dominated by smelt; gobies continue to increase in diets.
- Size of age-0 smelt increased. Decrease in age-1+ smelt size.
- Predator growth remains good.
- Round goby CPUE increased (158 to 613 ha^{-1} on soft substrate).
- Water temperature decreased; water clarity decreased; chlorophyll a decreased.

Central Basin

- Overall age-0 production increased
- Smelt, emerald shiners, yellow perch, and white perch increased. Alewife decreased.
- Predator diets dominated by emerald shiners; gobies continue to be prominent in diets.
- Size of age-0 smelt increased. Decrease in age-0 yellow perch and walleye size.
- Goby CPUE decreased to.
- Water temperature decreased; water clarity increased; chlorophyll a decreased.

Western Basin

- Strongest walleye year-class in 20 years, yellow perch year-class also very strong.
- Alewife virtually absent from surveys; emerald shiners continue to increase; good white perch and white bass production.
- Walleye diets dominated by clupeids.
- Size of all ages of yellow perch increased; size of age-0 walleye decreased.
- Goby CPUE decreased (60 ha^{-1} on soft substrate).
- Water temperature decreased; water clarity decreased; chlorophyll a decreased.

2.2 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 OMNR's index bottom trawl survey (ON-DW) and to a lesser degree during recent years of NYSDEC index trawl assessments. An increase in YAO smelt abundance was expected in 2003, and indeed was the observed outcome among all of the agency trawl surveys.

Young-of-the-year (YOY) smelt have remained the most abundant forage fish component in the absence of an abundant yearling cohort of smelt. YOY smelt abundance increased basin-wide in 2003. Densities of age-0 smelt were approximately 4 to 12 times higher in Long Point Bay region than in the southern regions of the basin surveyed by NYS DEC and PFBC. According to OMNR trawl assessment the 2003 year class of rainbow smelt was the strongest observed over the 20-year history of the survey. Mean length of Age-0 smelt increased and mean length of yearling smelt decreased in 2003 (Figure 2.1).

Several other species contributed to the size and diversity of the forage fish community of eastern Lake Erie in 2003 (Table 2.1). Most notable of these were emerald shiner, trout-perch, round goby, white perch and gizzard shad. Emerald shiner's, predominately YOY, made significant contributions to the East Basin forage base during 2003. This was particularly evident in Ontario and Pennsylvania where the 2003 year class was the strongest observed in the respective time-series of these surveys. Trout-perch continued to be a prominent component of the benthic fish community in southern regions of eastern Lake Erie particularly in New York's waters, but remained conspicuously sparse throughout the Long Point Bay area. Age-0 white perch were uncharacteristically abundant in 2003 agency trawl catches, especially in Pennsylvania's survey waters.

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 in the southern regions of the basin. This anomaly was short-lived as goby densities again resumed an upward trend throughout all survey areas during 2003 (Table 2.1).

During 2003, 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 walleye diets revealed that rainbow smelt have remained the dominant prey of walleye during each summer of NYS DEC assessment since 1993. Beginning in 2001 prey fish other than rainbow smelt began to make a small, but measurable, contribution to the walleye diet. During 2003 both clupeids and emerald shiners emerged as lesser contributors to the walleye diet. Similar to past years, fish comprised about 90% of the diets of both lake trout and burbot caught in experimental gillnets fished throughout coldwater habitat of eastern Lake Erie during August 2003. Smelt continued to be the dominant food item for lake trout, occurring in 76%

of all lake trout stomach samples. Burbot diets with 8 different fish and invertebrate species found in stomach samples were comparatively more diverse than that of lake trout. Smelt occurred in 20% of the 2003 burbot stomachs sampled but were replaced by round gobies as the most abundant food item. Round gobies are an increasingly important forage item for coldwater predators. They have increased in lake trout stomachs from none in 2001 to 4.6% in 2002, to 15.4% in 2003. Occurrences of gobies in burbot gut contents are even more substantial, increasing from 19.8% in 2001 to 29.6% in 2002, to 60.8% in 2003.

Age-2 and age-3 smallmouth bass cohorts sampled in 2003 fall gill net collections remained longer than average for New York's 23-year time series. Juvenile walleye (age-1 & age-2) and juvenile yellow perch (age-0 & age-1) remained near long-term averages for New York's length at age data series. Mean lengths-at-age and mean weights-at-age of lake trout continue to be consistent with the 5-year average (1998 – 2002). Lake trout growth in Lake Erie continues to be among the highest in the Great Lakes.

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

In the central basin, overall forage abundance increased three fold from 2002, due to the largest YOY cohort since 1996 (Table 2.2). In both Ohio and Pennsylvania, rainbow smelt, emerald shiners, yellow perch and white perch increased dramatically from 2002. Gizzard shad and trout-perch abundance also increased from 2002, but only in the eastern area for trout-perch and western area for the gizzard shad. In Pennsylvania, YOY round goby abundance decreased from 2002 and has decreased for the last two years. In Ohio, round goby abundance has remained stable since 2001.

Yearling-and-older forage abundance generally decreased from 2002 and reflects the poor cohort of that year. The only species that increased in both Pennsylvania and Ohio were emerald shiners. In Pennsylvania, both yellow perch and rainbow smelt abundance increased. In Ohio, round goby were the only other YAO forage species that increased in abundance. There are no apparent trends in YAO forage abundance in the central basin.

The only trends in YOY growth in the central basin were in rainbow smelt, walleye and yellow perch. Rainbow smelt have increased in size over the last two years and are slightly above the long term mean. Walleye and yellow perch have decreased in size over the last two and three years respectively. Both species are similar in size to the 1996 and 1997 cohorts.

Adult walleye diets (percent dry weight) in the fall were dominated by emerald shiner (62.3%), gizzard shad (21.6%) and rainbow smelt (12.9%) which is similar to the predominant prey species found in the trawl surveys. Round goby continue to be significant diet items in smallmouth bass (63%), yellow perch (48.7%), white perch (12.5%), and white bass (4.3%).

Water temperatures were cooler in the central basin in 2003, when compared to 2002. Secchi depth also decreased marginally. Low hypolimnetic dissolved oxygen (<4 mg/L) was observed on 2 occasions, August 5 and September 8. Total phosphorous concentration continued to increase in 2003, while basin wide chlorophyll a declined. Nearshore Secchi depths were generally lower than the last three years, a likely consequence of higher precipitation and runoff.

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

Percid recruitment was the strongest since the survey began in 1987 (Figure 2.2). Emerald and spottail shiner CPUE also increased (Figure 2.3). Clupeid CPUE decreased sharply (third lowest in the series; Figure 3.2, 3.3). Recruitment of white perch and white bass increased in August 2003 compared to 2002 (Figure 2.4), but the white bass trend declined by October. No YOY smallmouth bass were collected from Ohio waters in August or October 2003.

Round goby CPUE decreased in 2003 (Figure 2.5), although overall density has remained similar since 1998. 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.

Age-0 yellow perch size was the highest observed since 1998, exceeding the long-term average (Figure 3.4). Age-0 walleye size was the lowest observed since 1997, likely due to the high abundance of the 2003 year-class. Age-1 yellow perch were the largest since 1972 while age-2 were slightly larger than the previous year-class and similar to the long-term mean. However, age-2 walleye mean length and weight were slightly lower than those observed in 2002.

Despite the apparent absence of clupeids in fall trawling indices, walleye diets continued to be dominated by clupeids in the western basin (94% by volume), with minor contributions from shiners and smelt.

Average water temperatures were cooler in 2003 than those observed the previous year. Surface temperature peaked at 24.4 C as opposed to a three week period in July 2002 where surface temperatures exceeded 25 C. Dissolved oxygen concentrations remained high through the season (8.9 μg/L average). Secchi depth ranged from 0 to 4.0 m with an average of 1.8 m, down slightly from 2.4 m in 2002. Chlorophyll a concentrations averaged 5.1 μg /L (down from 6.7 μg /L in 2002) when the Sep 10 value of 175.9 μg /L associated with a large *Microsystis* algae bloom was removed

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 2004, Ohio is planning to use the SCANMAR equipment to measure midwater trawl configuration aboard the R / V Grandon.

3.2 Summary of Species CPUE Statistics (by T. Johnson, J. Tyson and J. Zhu)

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 72 trawls were used in the analyses in 2003 (Figure 3.1).

In 1992, the ITG recommended that the FTG review its interagency trawling program and develop standardized methods for measuring and reporting basin-wide community indices. Historically, indices from bottom trawls had been reported as relative abundances, precluding the pooling of data 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*, and SCANMAR was again employed to estimate the net dimensions in 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. The FTG will continue to recognize the strength of hydroacoustics to describe pelagic fish distribution and abundance, and has developed hydroacoustic programs for the east and central basins of Lake Erie. 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 are also being explored. The FTG has proposed a side-by-side comparison of available technologies (bottom trawl, mid-water trawl, conventional downward looking hydroacoustics, side-scan, and stationary upward looking sonar) in 2005 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. The *Trawl Comparison Exercise* outlined below describes a very successful program completed in 2003 that demonstrates the commitment of the Lake Erie agencies to standardization and direct comparison of programs between agencies.

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 program. 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 increased while biomass remained comparable in 2003, relative to 2002, owing primarily to strong production of spiny-rayed fishes in both Ohio and Ontario waters (Figures 3.2 and 3.3). Spiny-rayed species comprised 83% of the abundance and 74% of the biomass in 2003, much higher than the long-term (1987-2002) averages of 58 and 51%, respectively. Exceptionally strong year-classes of walleye, yellow perch, and white bass drove the trend in spiny-rayed catch. Smallmouth bass recruitment was very poor (3rd lowest in series). Clupeid catch declined dramatically in 2003, comprising only 6% of the total abundance, and 11% of the biomass compared to 29 and 40%, respectively, in the long-term. Alewife recruitment was the poorest observed since 1987, while gizzard shad recruitment was well below average. Soft-rayed catch remained unchanged relative to 2002, and comparable to the long-term averages. Emerald shiner catches were the highest observed, while spottail shiner catches were among the lowest in the series.

Mean length of age-0 fishes was down in 2003 (Figure 3.4), likely a direct response to the cooler water temperatures (see lower trophic level monitoring section). Higher density of age-0 piscivores may have increased demand for forage, further contributing to lower than average growth rates for these species. Length of age-0 for select species include: walleye (112mm), yellow perch (58 mm), smallmouth bass (53 mm), white bass (56 mm) and white perch (53 mm). Long-term averages for the same species are: walleye (137 mm), yellow perch (67 mm), smallmouth bass (82 mm), white bass (69 mm), and white perch (58 mm).

Spatial maps of forage distribution were constructed using site-specific catches (#/ha) of the functional forage groups (Figure 3.5). Abundance contours were generated using kriging contouring techniques to interpolate abundance between trawl locations. Abundance of clupeids was highest in the north central portion of the basin with a notable minima running east-west across the middle of the basin. In previous years, high density of clupeids extended southward along the west side of the island archipelago. Higher predator density (percids) and cooler water temperatures may in part explain this shift in distribution of the clupeids. Soft-rayed fish (predominantly emerald shiners and troutperch) were most abundant in the northwest portion of the basin, a pattern similar to that seen in previous years. Spiny-rayed abundance was distributed across the basin. Relative abundance of the principal species includes: yellow perch (44%), white perch (42%), white bass (10%) and walleye (3%). Total forage abundance averaged 5,264 fish/ha across the western basin, doubling from 2002, and returning to the long-term average. Clupeids averaged 301 fish/ha, soft-rayed fishes averaging 627 fish/ha, and spiny-rayed fishes averaging 4,327 fish/ha.

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

Introduction

Marine and freshwater fisheries research and management agencies routinely conduct long-term demersal trawling surveys for various purposes (Doubleday 1981; Lauth et al. 1998). Fisheries agencies use this information to estimate the condition of exploitable fish resources, to generate recruitment indices for exploitable fish stocks, or to track changes in the fish community over time. One common problem with these surveys, however, is the difficulty in administering them with a single vessel-gear combination, as well as maintaining the temporal continuity of abundance indices when vessels change (Doubleday 1981; Pelletier 1998; Wilderbuer et al. 1998). To account for differences in catchability across multiple vessel-gear combinations, agencies should: 1) incorporate pairwise/parallel trawling into the allocation of vessels by area for multi-vessel surveys, permitting comparison of fishing power; 2) maintain the same vessel over the time series, whenever possible; and 3) if/when old vessels are replaced by new ones, conduct calibration studies (Anonymous 1992). The requirement of a standardized Catch-Per-Unit-Effort (CPUE) is essential for producing abundance estimates from several vessel-gear combinations. In practice, standardization of CPUE entails calibration of the fishing powers of each vessel-gear combination and subsequent correction of the CPUE data to the reference vessel-gear combination (Wilderbuer 1998). The objective of the following experiment was to develop fishing power correction (FPC) factors for a multi-agency survey in the western basin of Lake Erie, and to use an objective decision rule when applying the FPC factors to correct the CPUE data.

Scientific trawling surveys have been an important source of information for fisheries agencies on Lake Erie for a number of years (Deller et al. 2003). Various state, provincial and federal agencies conduct trawl assessment programs in the western and central basins of Lake Erie, with some programs initiated in the 1960s (Figure 3.6). Agencies use these data primarily to generate abundance indices for age-0 walleye and yellow perch. Additionally, these data are incorporated into population modeling exercises as an index of recruitment, which is then used by the Walleye and Yellow Perch Task Groups for quota allocation purposes (Thomas et al. 2003; Cook et al. 2003). Agencies also generate abundance indices for a number of other species (primarily young-of-the-year) in the community in both basins to track changes in the fish community (Deller et al. 2003).

The majority of the trawling programs in the west and central basin operate independently, and generally sample different jurisdictional areas within each basin with one notable exception. The Interagency Trawling Program, a cooperative trawling program conducted by the Ontario Ministry of Natural Resources (OMNR), and the Ohio Department of Natural Resources (ODNR) began in 1987 (Knight et al. 1993). The primary objective of this program is to generate a basinwide index of age-0 percid abundance, however, abundance information on all aspects of the forage fish community are also collected. The interagency trawling program is a depth stratified random sampling design with approximately 80 sampling sites distributed across the western basin. Sampling gear (trawls), procedures (trawl speed, warp, tow duration etc.) and catch processing protocols were standardized across agencies, but differences between the ODNR and OMNR vessels existed, the RV Gibraltar and RV Keenosay, respectively. Additionally, in 2002, ODNR acquired a new research vessel (RV Explorer), however Ohio Sea Grant (OSG) purchased the old research vessel (RV Gibraltar), and it was made available for a calibration experiment to preserve the temporal continuity of the data series. Other trawling programs in Lake Erie include a trawling program administered by the USGS using the RV Musky, from 1961-present, and a central basin trawling program administered by ODNR using the RV Grandon from 1990-present.

The ability to combine data from not only the Interagency trawling program, but also from the other trawling programs into a single trawling index in the western basin was desired for several reasons. First combination of the surveys should capture trends in abundance basinwide (across jurisdictional boundaries). Second, a larger sample size should translate into more precise abundance estimates across the basin (Neter et al. 1990). Third, combination of these surveys should help to account for known spatial trends across and within sampling areas. Lastly, the ability to compare estimates of abundance from the west and central basins is important to fisheries management agencies as well.

However, before combining these trawling programs into a single estimate, the Lake Erie agencies recognized that it might be necessary to correct for differences in fishing power (Gulland 1956; Beverton and Holt 1957; Lauth et al. 1998; Wilderbuer et al. 1998; von Szalay and Brown 2001) between the different vessel-gear combinations conducting the surveys. Catches resulting from any fishing operation are dependent on three factors: 1) vessel and fishing characteristics, e.g. fishing gear, technology, crew etc.; 2) characteristics of the sampled populations, e.g. abundance level, spatial distribution etc.; and 3) environmental conditions, e.g. weather, depth, substrate etc. Identifying the influence of each of these separate effects is important to interpretation of catch data across vessel-gear combinations. The design of intercalibration experiments should minimize the sources of variability associated with spatial distributions and environmental conditions. Most intercalibration experiments are conducted based upon paired hauls (side-by-side). Conducting paired hauls (generally with vessels within ¼ to 1 nautical mile of each) should theoretically reduce the variability associated with fish spatial distributions and environmental variability, such that the primary source of variability is that associated with the vessel and fishing gear.

One final factor that must be considered when correcting for fishing power differences is the added variability associated with the fishing power correction (FPC) factor itself. Correcting for fishing power differences is worthwhile only when it reduces the error in the estimate of the mean CPUE. It is quite possible to have a statistically significant difference in fishing power and still not apply an FPC since the added variance may exceed the benefits of reduced bias. If the estimate of a correction factor has a lot of uncertainty, then the error of the estimate of mean CPUE could become worse by correcting the data.

Due to the complexity of the sampling programs across the basin, and the need to preserve the agency and interagency time series due to vessel changes, participating Lake Erie fisheries agencies agreed to participate in an intercalibration experiment to develop trawl correction factors for the most commonly sampled species-age classes in western Lake Erie. In addition to development of trawl correction factors, the Lake Erie agencies also established a decision rule for application of the aforementioned trawl correction factors based upon the Mean Square Error (MSE) as outlined by Peter Monro (1998). In August 2000, the Forage Task Group, in conjunction with the Ohio Chapter of the American Fisheries Society sponsored a workshop on trawl calibration techniques, including field considerations, FPC estimators, and application of the objective decision rule based on the MSE (Monro 1998). The expert highlighted several points that needed consideration when conducting this type of study, primarily the choice of sampling design, approaches to data analysis, and the decision rule for application of the FPC factors.

The objectives of this study were to estimate the differences in fishing power between five research vessels sampling west and central Lake Erie in order to combine data from several ongoing trawling surveys, as well as preserve the temporal integrity of those surveys. Additionally, we will apply an objective decision rule to determine the suitability of applying the FPCs for the most frequently collected species age-groups.

Methods

Vessels and Gear

The interagency bottom trawl program has been conducted by ODNR and OMNR in the western basin of Lake Erie since 1987 to estimate percid recruitment indices using the RV Gibraltar, RV Explorer and RV Keenosay (Figures 3.6 and 3.7). This program provided for standardized trawling gear and processing protocols at its inception, however, the three fishing vessels conducting the surveys varied markedly in their designs and configurations. The standard bottom trawl fished by OMNR, ODNR and OSG is a modified two-seam Biloxi bottom trawl with a 10.3 m headrope, 11.8 m ground line, and a 13 mm mesh codend liner. The bottom trawl fished by the RV Musky (USGS) over their time series is slightly different than those fished by the above three vessels (Figure 3.7). Their bottom trawl is a slightly smaller version of the two-seam modified Biloxi trawl with a 7.9 m headrope and a 13 mm mesh codend liner. The bottom trawl fished by the RV Grandon (ODNR) differed most from the other standard nets because of habitat differences in the central basin, relative to the western basin. The trawl fished by the RV Grandon is a Yankee two-seam bottom trawl with a 10.4 m headrope, 13-mm mesh codend liner, and 25.4 cm roller gear. Standard tow speed was 1.5-2.0 knots for all vessels except the RV Grandon, which trawled at 2.5 knots. The duration of all trawl hauls was 10 minutes for all vessels except the RV Grandon. Due to the higher trawling speed (and greater distance covered at this speed) the haul duration for the RV Grandon was reduced to 5 minutes, from their standard of 10 minutes.

Experimental Design

Prior to the experiment, all agencies agreed that vessels would fish their standard gear configurations as they normally would have over their time series. Additionally, we selected the RV Keenosay as the "standard" vessel, such that CPUE values from all other vessels would be corrected to those of the RV Keenosay. It was determined that all five vessels were to tow side-by-side, generally within ½ mile of each other for a series of three trawl hauls. Then the vessels would return to their original starting location (or a different location depending upon wind conditions), the order of the vessels would be randomized, and the vessels would commence with another series of three hauls. This design would be repeated over the three-day period and should generate approximately 50 side-by-side hauls for generation of the FPCs.

Bottom trawl catches were to be sorted by species and age group based upon pre-assigned length-age group keys distributed to all vessels prior to the exercise. Targeted species (e.g. walleye, yellow perch, white perch, and white bass) were assigned to three age groups including age-0, yearling, and adult, while all other species were assigned to two age groups, age-0 and yearling-adult. All species-age groups were enumerated. On the third haul of each sequence, catches were sorted into the above age groups and enumerated, and 30 individuals from each species-age group were measured to the nearest millimeter.

Because low and zero catches of targeted species are less informative in estimating FPCs (Wilderbuer et al. 1998), we selected sampling locations for the intercalibration experiment that maximized the probability of high percid catch rates, provided ample trawling grounds for a series of side-by-side trawl hauls, and minimized the travel time from dockage to trawling grounds. Using the interagency trawling data from previous years, two 2.5 minute grid locations were selected for the exercise (Figure 3.8).

For development of FPCs each vessel represented CPUE data as catch per hectare. Each vessel estimated distance fished from recorded latitude and longitude coordinates after net deployment (at brake set), and before net haul back (effectively the 10 minute tow period). Estimates of area swept were generated from information on distance towed, as well as trawl wing spread, which was estimated using SCANMAR net mensuration equipment during independent exercises sponsored by the Forage Task Group (Witzel et al. 1996, Einhouse et al. 1998).

Fishing Power Correction Factor

Several analytical techniques have been used to obtain estimates of fishing power correction (FPC) factors (Wilderbuer). For our initial analyses, we chose to estimate the FPC using the "ratio of mean CPUE of the standard vessel to the mean CPUE of the other vessels" for each species age-group combination calculated as:

$$R = \frac{\frac{1}{n}\sum_{j=1}^{n} CPUE_s}{\frac{1}{n}\sum_{j=1}^{n} CPUE_{ns}};$$

Where R is the ratio estimate, n is the number of haul pairs, j indexes haul pairs, $CPUE_s$ is the CPUE of a species age group from the j^{th} haul made by the "standard" vessel, and $CPUE_{ns}$ is the CPUE of the same species age group from the j^{th} haul made by the "non-standard" vessel. Again, in our experiment, we selected the RV Keenosay as the standard vessel, such that CPUE data from all other vessels were corrected to the CPUE data from the RV Keenosay. Because little information on the FPCs was generated from zero catches, any of the paired j^{th} hauls that had either a zero value, or were missing (due to hang ups, etc.) were eliminated from the calculation of the FPC. The "ratio of mean CPUEs" estimator was selected to calculate the FPC because it is intuitive and easy to compute, has a well defined variance (Neter et al. 1990), and has been frequently cited in the literature (Koeller and Smith 1983; Wilderbuer et al. 1998). However, this FPC factor estimator is moderately sensitive to outliers.

Decision Rule

Monro's (1998) decision rule for applying a fishing power correction to CPUEs is based on the mean square error (MSE). The MSE is a measure of the error between an estimator and its parameter and can be represented as the sum of the variance and the squared bias of the estimator (Neter et al. 1990):

$$\mathrm{MSE}[\hat{C}] = \mathrm{Var}[\hat{C}] + \mathrm{bias}^2[\hat{C}];$$

where $\hat{C}$ is the estimator of the mean CPUE. According to the decision rule, an FPC should only be applied if:

$$\mathrm{MSE}[\mathrm{CPUE}_{\mathrm{corrected}}] < \mathrm{MSE}[\mathrm{CPUE}_{\mathrm{uncorrected}}];$$

where $\mathrm{CPUE}_{\mathrm{corrected}}$ and $\mathrm{CPUE}_{\mathrm{uncorrected}}$ are the mean CPUEs based on corrected and uncorrected CPUE data.

The decision rule developed by Monro (1998) was implemented as follows. We simulated surveys by drawing 100 sets of 50 CPUEs for the standard vessel (RV Keenosay) from the gamma distribution. No other probability density functions were examined in the initial analyses, however, other distributions will be examined in the future. The gamma distribution has been proposed as an appropriate distribution for data that is highly right skewed, primarily because of its ability to assume a variety of distinctly different shapes (von Szalay and Brown 2001). The particular members of the gamma family of distributions were derived from the mean (λ) and variance (τ^2) of the RV Keenosay CPUE data. The gamma random number generator function in SAS (SAS) requires the shape (α) and scale (β) parameters which are related to (λ) and (τ^2) as follows:

$$\alpha = \frac{\lambda^2}{\tau^2}$$

and

$$\beta = \frac{\tau^2}{\lambda}$$

(Rothschild and Logothetis 1986).

A fishing power difference (FPD) was then imposed upon a second set of CPUEs, that were drawn from the same distribution as above. This consisted of multiplying the CPUE data from the simulated survey by a constant FPD. This was done to simulate a potential catchability difference between the “standard” vessel and the “non-standard” vessel. An FPC was estimated for each simulated survey (each imposed FPD) as the “ratio of the mean CPUEs”. The “non-standard” vessel CPUEs were then multiplied by the FPC to “correct” for the differences in fishing power relative to the “standard” vessel.

The mean CPUE for each simulated survey was then estimated with and without correcting for the imposed FPD. This yielded two data vectors containing 100 observations of the mean CPUE for uncorrected data, and the corrected data. From these vectors, an uncorrected and corrected mean ($\hat{C}_{\text{corrected}}$ and $\hat{C}_{\text{uncorrected}}$) and variance ($\theta_{\text{corrected}}$ and $\theta_{\text{uncorrected}}$) were computed. The bias for each of the corrected and uncorrected data was estimated as

$$b = [\hat{C}_{\text{corrected[or uncorrected]}}] - [\hat{C}_{\text{obs}}];$$

where b is the bias, [$\hat{C}_{\text{corrected or uncorrected}}$] is the mean CPUE from the corrected and uncorrected simulation survey, and [$\hat{C}_{\text{obs}}$] is the observed mean CPUE from the side-by-side trawl experiment for the “non-standard” vessel. MSEs for the corrected and uncorrected simulations were estimated as:

$$\text{MSE}_{\text{corrected [or uncorrected]}} = (b_{\text{corrected [or uncorrected]}})^2 + \theta_{\text{corrected [or uncorrected]}}$$

This process was repeated for a range of imposed FPDs (Figure 3.9), and the resulting MSEs for both the corrected and uncorrected cases were plotted against the imposed FPD. Using this decision rule, the plots were used to establish ranges of FPDs (correction regions) for which an FPC was warranted.

Results and Discussion

We conducted the intercalibration trawling experiment near the Bass Islands in western Lake Erie from August 26-28, 2003. Depths ranged between 9- and 11-m. As stated above, each vessel employed their standard trawling methods during the experiment. Two hundred and thirty two total trawl hauls were collected by the five vessels during the three-day intercalibration experiment (Figure 3.10). Both the RV Keenosay and RV Explorer successfully completing 51 paired hauls apiece, the RV Musky successfully completed 50 trawl hauls, the RV Gibraltar completed 45 trawl hauls, and the RV Grandon completed 34 trawl hauls. Over the three-day period, the five vessels caught approximately 130,000 fish. The standard vessel recorded age-0 walleye and yellow perch in all trawl hauls, with other vessels having the two targeted species age-groups in most of their trawls as well (Table 3.1). Despite the high number of trawls conducted in this area, there was no evidence of depletion of targeted or non-targeted (Figure 3.11) species within the sample area.

Ten species age-groups comprised over 95% of the trawl catches, therefore FPCs were developed for these 10 species age-groups. Most FPCs were developed based on > 30 paired hauls, however, due to low abundance, the FPC for gizzard shad was computed based on very few hauls. Because of the low sample sizes for generating this FPC, we have low confidence in the applicability of the FPC values for this species. A case in point, despite the apparent inefficiency of the standard vessel in sampling gizzard shad (FPC values ranged from 0.76-0.22), gizzard shad were recorded in 25 trawl hauls by the RV Keenosay, versus 4-12 trawl hauls by the other research vessels.

In general, the RV Grandon was the most efficient vessel-gear combination of the five that were involved in the experiment. This was not surprising given that the RV Grandon trawled at 2.5 knots, versus 1.5-2.0 knots for the other vessels. Higher tow speeds most likely minimize the amount of escapement (Azarowitz 1981) of targeted species. The three research vessels that currently or historically participate in the Interagency Trawling Program fished most similarly to each other. Generally, FPC factors rarely varied by more than 50% of the standard vessel's CPUE for these vessels and was most likely a function of the standardized fishing equipment and sampling protocols for the Interagency Trawling Program. The two vessels that did exhibit apparent differences in efficiency (the RV Grandon and RV Musky II) were trawling with very different equipment and using different trawling procedures.

Despite apparent differences in the efficiency of the vessels involved in the comparative trawling experiment using the FPC estimator that we selected (Table 1), there was little evidence of systematic bias in any of the species age-groups sampled by the five research vessels. Catches for most of the vessels were not consistently higher or lower than those of the standard vessel. Two notable exceptions were CPUE values of the RV Musky for age-0 walleye and white perch relative to the standard vessel (Figures 3.12 and 3.13). Reasons for the systematic bias (e.g.. the RV Keenosay always caught more age-0 walleye than the RV Musky) are not known, but may be related to do the bottom tending capabilities or the gape height of the trawl that the RV Musky fishes, relative to that of the RV Keenosay.

Due to time constraints, MSE decision curves were constructed for age-0 yellow perch and walleye only (Figures 3.14 and 3.15). In all of the cases, a region of increased estimation error was successfully identified and each included the value of 1.0, which represents identical fishing power. Non-correction regions for age-0 yellow perch were generally narrower than those for walleye. For all curves, the non-correction region differed in their symmetry about the value of 1.0, which is most likely due to an interaction between the mechanism for imposing the FPD on the simulated data and the sensitivity of the arithmetic mean to rare, extreme observations (Monro 1998). Using this decision rule, application of FPCs to age-0 yellow perch CPUEs would reduce overall error of the estimate for two vessels, the RV Gibraltar (FPC=1.321) and the RV Grandon (FPC=0.808). For age-0 walleye, all FPC values were outside of the range non-correction region, indicating that correction for efficiency is necessary for all vessels (Figure 3.16).

Decision curves will be developed for the other species age-groups caught during the intercalibration experiment and used to determine if application of the FPC values listed in Table 1 will reduce the overall error of the estimates of CPUE. For this exercise, only the gamma distribution was fitted to the CPUE data. Based solely upon visual examination, the gamma distribution appeared to fit relatively well, but other probability density functions must be explored. A poor fit of the data to the selected probability density function may have resulted in the highly skewed non-correction curves for age-0 walleye (Figure 3.15). Additionally, Wilderbuer et al. (1998) recommended the use of the Kappenman technique for estimating the FPC because it is more robust and less sensitive to rare large catches, relative to the “ratio of the means” FPC estimator that we used in this study.

When fisheries biologists analyze multi-vessel survey data, it is essential that standardized CPUE data be produced which addresses potential differences in fishing power among vessels. Without reference to this, trends in species abundance across time and vessels is suspect. Additionally, the decision to apply an estimated FPC is difficult because of the uncertainties associated with this estimate as well. We successfully developed FPCs for the majority of species age-groups collected in ongoing trawling surveys in the west and central basin, and demonstrated the application of an objective decision rule for determining whether to apply the FPCs. The Lake Erie agencies involved in this study also demonstrated that inter-jurisdictional sampling issues can be successfully addressed through cooperation and careful planning.

Acknowledgements

We thank the vessel captains and crew members of the RV Explorer, RV Gibraltar, RV Grandon, RV Keenosay, and RV Musky II for making this exercise a success, as well as Paul von Szalay (NOAA) for conducting the trawl comparison workshop in 2000. Additionally, the Ohio Department of Natural Resources, the Ontario Ministry of Natural Resources, Ohio Sea Grant, and the U.S. Geological Survey provided funding and logistics support. We would also like to acknowledge the Lake Erie Forage Task Group of the Lake Erie Committee, and the Ohio Chapter of the American Fisheries Society for providing support for this work.

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4.0 **Acoustic Survey Program**

4.1 East Basin Acoustic Survey (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 pelagic forage fish stocks in eastern Lake Erie. Surveys from 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, ongoing summertime acoustic survey efforts 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 (GLFC). The 1998 and 1999 survey years included broader seasonal coverage during spring (June), summer (July) and fall (October) assessment efforts. After 1999, only the long term July acoustic survey was continued as a standard, long-term measure of pelagic forage fish density and distribution in eastern Lake Erie. Throughout this acoustic monitoring program data collection has been coordinated among Forage Task Group member agencies with several research vessels (Argo, Erie Explorer, Keenosay, Musky II, and Perca) participating in various aspects of the data collection and calibration. Annual data analysis has been principally coordinated among the Ontario Ministry of Natural Resources and New York State Department of Environmental Conservation.

Beyond maintaining the long-term summertime eastern basin survey program, the Forage Task Group has been very actively pursuing initiatives to address survey design and analysis procedures to maintain an up-to-date and defensible scientific method for ongoing surveys. Through a GLFC grant (Einhouse and Witzel 2003) Lake Erie's Forage Task Group acquired a site license for new acoustic signal processing software. This grant also supported accompanying software training for selected members of the Forage Task Group. Subsequently, the newly trained individuals led a workshop to introduce this software to other biologists connected with fisheries acoustic surveys on Lake Erie. Two Forage Task Group members remain ongoing participants in a GLFC-sponsored Great Lakes Acoustic Study Group charged with preparing an array of standard operating procedures for ongoing Great Lakes acoustic investigations. In addition, Lake Erie acoustic surveys have contributed to four recent publications advancing our approach to survey design (Conners 1999, Conners and Schwager 2002), abundance estimation (Rudstam et al. 2003), and comparing density estimates through a time series that employed different acoustic systems (Rudstam et al. 1999). Finally, the Forage Task Group members have recently begun building post-processing applications in SAS software (SAS 1992) for implementing these new analytical procedures.

Methods

The 2003 summertime east basin acoustic survey effort was completed from July 21 to 29, 2003 (Figure 4.1). 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*). In all, 11 transects, spanning a total distance of 153.9 nm, were surveyed during this period. The companion mid-water trawling component of this survey was conducted aboard the *RV Argo* using a mid-water trawl with fishing dimensions of 36 m^2. Unfortunately, a major hydraulic failure on the *RV Argo* greatly abbreviated the 2003 trawling portion of this survey. Only four epilimnion trawl tows collected on one survey night comprised the 2003 trawling effort.

Results

Presentation of eastern basin acoustic survey results has been suspended while the principal investigators remain immersed in other initiatives pertaining to survey design and data processing/analysis methods (see Introduction). New standard analysis procedures will be applied to the time series beginning from 1997 and up-to-date survey results are planned to resume for the ensuing Forage Task Group reporting cycle in March 2005.

Discussion

A more thorough analysis of acoustic survey results was planned for several years but annual constraints on staff time had repeatedly postponed undertaking this more comprehensive analysis of the entire time series of acoustic data. However, major hurtles have now been addressed in this past year with; 1) the acquisition of new signal processing software and requisite training, 2) automating significant post-processing data management and analysis steps in SAS, and 3) achieving consensus on an appropriate methodology for estimating fish densities and expressing estimate precision. Prospects for completing and reporting this initiative as a separate document for the March, 2005 Lake Erie Committee meeting now appears much improved.

Finally, Lake Erie's fisheries acoustic applications and needs are expanding. A survey was recently initiated in the Central Basin and it is anticipated a Western Basin pilot survey will be underway in the near future. The ongoing eastern basin survey has a time series that now spans 11 years. Lake Erie's Forage Task Group currently shares one acoustic system and one signal processing site license among five Lake Erie jurisdictions. Also, the Lake Erie echosounder purchased in 1996 is no longer manufactured, and its long-term function will remain an issue. As such, continued support will be required to efficiently administer these surveys. This inter-agency acoustic monitoring program will require periodic upgrades, expansion of site licenses, and ongoing training of personnel to remain as a functional fish stock assessment tool for Lake Erie.

4.2 Central Basin Acoustic Survey

(by J. Deller, M. Bur, T. Johnson, and M. Stapanian)

In July of 2003, the FTG was able to complete two of three planned acoustic transects in the central basin. Due to weather constraints, acoustic work was canceled mid way through the second transect. Sample design for the 2003 survey was similar to surveys conducted in 2000 and 2001, where three cross basin transects were run along Loran-C TD lines (Figure 4.2). Midwater trawling was also conducted concurrent to the acoustic data collection from separate vessels. Prior to 2003, acoustic data collection was done aboard the R/V Erie Explorer and trawling was conducted aboard the R/V Keenosay. In 2003 we were able to coordinate and expand data collection among three member agencies. Acoustic data collection was conducted aboard the R/V Musky II at a vessel speed of 5 to 6 knots, using a Simrad EY-500 echosounder and 120 kHz transducer similar to the unit that is used in the eastern basin survey and previous central basin surveys. Acoustic data were collected over 91.3 nautical miles during the three night survey. Data files were limited to 5 megabytes due to the need for flexibility and constraints of the processing software. Midwater trawling was conducted concurrent to the acoustic data collection aboard the R/V Keenosay and R/V Grandon. Each vessel trawled on their respective side of the international border to maximize sampling time. A total of 21 trawls and 18 temperature and dissolved oxygen profiles were collected during the survey.

Preliminary analysis and discussion with Drs. Lars Rudstam and Dave Warner at the FTG hydroacoustic workshop (Port Dover, ON, Dec. 3-4, 2003) revealed that spatial coverage might be more valuable than the shore to shore coverage that we have done in the past and that a sample design with shorter paired transects might better suit the hydrology of the central basin. It was suggested that a sample design with two paired transects within a series or groups of randomly selected 10 minute grids would improve spatial coverage and biomass estimates compared to our current sampling regime. One of the draw backs to this design is the amount of extra time required to travel among transects and grids, possibly extending the survey by several days. A second design that was discussed was to increase the number of cross basin transects to nine. It was felt that, with nine transects, we would acquire better spatial data and equally robust biomass estimates compared to the paired transects within a ten minute grid design. We are also exploring possibility of acquiring an additional vessel, the R/V Sturgeon, from USGS to help with the acoustic portion of the survey. We are currently working on the feasibility and logistics associated with both sample designs and additional vessels, and will incorporate appropriate changes to the 2004 acoustic survey, scheduled for the last two weeks of July, 2004.

Analysis of the 2003 central basin acoustic and trawl data was not complete at the time this report went to press. Additional acoustic and midwater trawl data collected in the 2000 and 2001 pilot surveys will be included in future analysis and reports.

Acknowledgments

The FTG is grateful to research vessel captains Gordon Ives (OMNR) and Douglas Zeller (NYS DEC) for their efforts in executing this all night survey program under often uncomfortable or difficult conditions.

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5.0 Interagency Lower Trophic Level Monitoring Program

(by B. Trometer and T. Johnson)

Introduction and Methods

In 1999, the FTG initiated a 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. The year 2003 marks the fifth year of this monitoring program. For this report, we will summarize the last five years of data for four variables for which there is sufficient data. These variables are epilimnetic temperature, Secchi depth, total phosphorus and chlorophyll a. Stations were only included in the analysis if there were at least 3 years each containing 6 or more sampling dates. Stations included in this analysis are 3, 4, 5 and 6 from the western basin, 9, 10, 13 and14 from the central basin, and 15, 16, 17, 18, 19 and 20 from the eastern basin (Figure 5.1).

Results for 2003

Epilimnetic Temperature

Epilimnetic temperature was recorded 1 meter below the water surface at each station. In general, temperatures decline from west to east (Figure 5.2), although the east basin temperatures were warmer than the central basin in 1999 and 2000. Trends in the west and central basins have been similar across the years, while the east basin epilimnetic temperature has steadily declined over the 5 year period of record. There are no differences in observed temperature between nearshore and offshore stations.

Secchi Depth

Secchi depth declined in all basins in 2003 relative to 2002 (Figure 5.3), possibly related to higher precipitation increasing runoff and sediment load. As expected, Secchi depth was lowest in the west basin, and highest in the east basin. The average annual Secchi depth in the offshore stations of the west and central basins was at least 0.5 m higher than at the nearshore stations. This pattern was not evident in the east basin.

Total Phosphorus

Total phosphorous (TP) concentration increased in all basins in 2003, relative to 2002 (Figure 5.4). Basin wide increases were greatest in the central basin. Total phosphorus concentration was highest in the west basin and lowest in the east basin. The difference in TP between west and central basin is decreasing in recent years. Station 4 (off Maumee River) had the highest total phosphorus readings in each year.

Chlorophyll a

Chlorophyll a results showed a similar interbasin pattern of decline from west to east (Figure 5.5). There is little temporal trend in the east basin, while the central basin appears to be lagged one year behind the west basin. Stations 3 and 4 (off the Maumee River) yield the highest chlorophyll readings of any station on the lake, which may be a reflection of the nutrient loading originating in this watershed.

At present, the FTG is evaluating a series of ecological indices based on lower trophic level parameters to judge their performance using our dataset. We expect to report on some of these indices in the 2005 annual report.

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 6.6). 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. Only goby distributions from 2002 and 2003 are presented in this report. Please see the 2003 Forage Task Group Report for figures and descriptions of goby distribution prior to 2002 (Deller et al. 2003). A base map showing grids, boundaries and areas trawled is provided in figure 6.1 for reference.

In 2003 round goby densities continued to increase in most areas of the eastern basin. Round goby abundance in the remainder of the lake tended to decline or remained stable, relative to the previous year.

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Deller, J., and 10 co-authors. 2003. Report of the Lake Erie Forage Task Group to the Standing Technical Committee, Lake Erie Committee, Great Lakes Fishery Commission. 24p.

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 2002 and 2003. 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**	**2003**	**2002**	**90's Avg.**	**80's Avg.**	**2003**	**2002**	**90's Avg.**	**80's Avg.**
Smelt	ON-DW	7120.0	148.4	475.7	1382.9	218.0	5.6	405.0	969.0
	NY-Fa	1733.4	1606.6	1450.9	NA	282.1	117.0	581.6	NA
	PA-Fa	592.2	98.0	550.8	7058.1	32.4	6.5	378.0	2408.6
Emerald Shiner	ON-DW	3508.5	9.5	53.6	20.5	209.9	245.0	46.2	38.1
	ON-OB	146.4	18.9	113.0	152.3	19.5	19.6	47.7	133.3
	NY-Fa	229.7	19.5	112.4	NA	444.5	466.4	105.4	NA
	Pa-Fa	1163.4	74.4	41.0	118.3	157.6	105.7	14.5	45.6
Spottail Shiner	ON-OB	36.3	12.2	696.9	249.3	4.0	11.9	52.6	21.6
	ON-IB	0.3	0.0	113.3	292.6	0.6	0.5	2.0	9.5
	NY-Fa	13.2	1.0	19.9	NA	4.8	34.2	4.0	NA
	PA-Fa	0.0	0.0	4.0	2.0	0.0	0.8	7.9	12.4
Alewife	ON-DW	0.6	35.5	124.7	21.4	NA	NA	NA	NA
	ON-OB	8.1	13.4	60.9	51.4	NA	NA	NA	NA
	NY-Fa	3.9	617.6	52.0	NA	NA	NA	NA	NA
	PA-Fa	2.5	0.8	7.7	16.6	NA	NA	NA	NA
Gizzard Shad	ON-DW	69.6	3.2	5.1	15.3	NA	NA	NA	NA
	ON-OB	3.3	1.5	9.6	24.2	NA	NA	NA	NA
	NY-Fa	27.8	5.5	4.2	NA	NA	NA	NA	NA
	PA-Fa	0.0	0.8	0.9	74.3	NA	NA	NA	NA
White Perch	ON-DW	69.6	3.2	5.1	15.3	NA	NA	NA	NA
	ON-OB	3.3	1.5	9.6	24.2	NA	NA	NA	NA
	NY-Fa	27.8	5.5	4.2	NA	NA	NA	NA	NA
	PA-Fa	0.0	0.8	0.9	74.3	NA	NA	NA	NA
Trout-perch	ON-DW	0.0	0.0	0.1	0.5	2.7	0.6	0.5	1.9
	NY-Fa	1392.6	886.0	410.0	NA	NA	NA	NA	NA
	PA-Fa	230.6	0.0	23.2	NA	26.0	0.0	26.0	NA
Round Goby [a]	ON-DW	158.3	123.4	0.0	0.0	NA	NA	NA	NA
	ON-OB	55.9	96.4	0.1	0.0	NA	NA	NA	NA
	ON-IB	20.5	47.8	0.0	0.0	NA	NA	NA	NA
	NY-Fa	321.0	75.8	1.0	0.0	292.4	60.1	0.0	0.0
	PA-Fa	323.5	18.2	30.3	0.0	63.8	25.7	5.6	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 1990-2003.

		Year														
Species	**Agency**	**1990 [a]**	**1991 [a]**	**1992 [a]**	**1993 [a]**	**1994 [a]**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**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	0.0	13.1
	PA	0.0	-	174.3	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	14.6
Gizzard Shad	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	169.5	38.1
	PA	40.9	-	0.0	-	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6
Rainbow Smelt	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	3101.5	726.8
	PA	1128.2	-	8205.0	-	952.9	106.7	5422.1	10.3	29.9	1.8	15.3	377.4	152.9	177.7	1381.7
Emerald Shiner	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	411.9	234.5
	PA	366.5	-	33.6	-	0.0	53.6	3.5	0.0	5.8	0.0	0.0	8.5	38.1	81.8	49.2
Spottail Shiner	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	0.2	3.3
	PA	0.0	-	0.0	-	0.0	19.9	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	1.7
Trout-Perch	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	1.6	6.6
	PA	0.0	-	214.1	-	1.1	24.9	7.1	0.0	23.1	10.0	23.0	7.8	45.7	78.0	36.2
White Perch	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	165.7	391.6
	PA	1527.6	-	887.5	-	76.3	136.0	331.5	0.0	0.0	8.5	75.9	26.6	80.7	173.7	277.0
White Bass	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	110.2	48.9
	PA	16.6	-	0.0	-	6.6	4.4	0.0	0.0	0.0	0.0	96.4	12.1	0.0	0.0	11.34
Yellow Perch	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	103.5	39.1
	PA	8.6	-	124.8	-	567.4	52.0	354.1	0.0	13.7	7.2	15.7	388.4	11.9	788.0	194.3
Round Goby	OH	-	-	-	-	3.0	29.3	35.1	98.7	171.6	128.9	81.3	41.4	44.8	42.0	67.0
	PA	-	-	-	-	-	-	0.4	1.5	743.6	1114.4	781.1	1577.8	289.4	75.3	572.9

[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 1990-2003.

		Year													
Species	**Agency**	**1990 [a]**		**1992 [a]**	**1993 [a]**	**1994 [a]**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
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	0.0	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	0.5	5.2
Gizzard	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	1.2	0.7
Shad	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	0.1
Rainbow	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	73.2	155.7
Smelt	PA	43.1	-	540.6	-	4.4	506.0	29.9	25.6	1.34	0.0	75.8	0.0	6.2	22.1	104.7
Emerald	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	154.8	161.9
Shiner	PA	2.8	-	240.7	-	0.6	17.7	0.0	0.0	0.0	0.0	0.0	0.0	107.4	217.5	49.5
Spottail	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	1.0	5.4
Shiner	PA	18.2	-	0.0	-	0.0	17.7	0.0	0.0	0.4	0.0	0.0	0.0	2.2	0.0	3.2
Trout-	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	5.6	10.8
Perch	PA	64.2	-	132.7	-	7.2	53.1	0.0	8.9	1.0	0.9	11.5	0.6	81.2	50.9	34.3
White	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	18.9	57.8
Perch	PA	42.0	-	61.5	-	0.0	1.7	1.8	0.0	0.0	1.9	0.6	2.4	38.5	28.6	14.9
White	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	3.0	3.5
Bass	PA	5.0	-	0.4	-	2.8	0.0	0.0	0.0	0.0	6.0	1.0	57.6	0.4	0.0	6.1
Yellow	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	2.3	31.7
Perch	PA	50.9	-	57.5	-	2.2	191.9	12.4	14.6	2.6	7.9	3.9	41.3	37.5	75.6	41.5
Round	OH	-	-	-	-	2.7	51.5	142.4	331.8	150.6	98.9	81.0	88.3	44.0	85.9	107.7
Goby	PA	-	-	-	-	-	-	0	0	113.1	55.3	126.5	55.2	238.3	59.1	81.0

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

Table 3.1. Fishing Power Correction factors for the ten most frequently caught species age-groups in trawls during the intercalibration experiment. Sample sizes (n) represent the number of paired hauls used to estimate the FPC.

Vessel	**Age-0 Yellow Perch**	**Age-0 Walleye**	**Age-0 White Perch**	**Age-0 White Bass**	**Yearling-Adult Yellow Perch**	**Goby**	**Yearling-Adult Drum**	**Emerald Shiner**	**Age-0 Trout-Perch**	**Age-0 Shad**
Explorer **(n)**	0.933 (51)	1.561 (51)	1.137 (50)	3.092 (32)	0.727 (44)	0.426 (43)	0.619 (47)	1.611 (40)	0.701 (48)	0.756 (6)
Gibraltar **(n)**	1.321 (45)	1.519 (45)	0.991 (43)	1.641 (34)	0.913 (39)	1.044 (39)	1.487 (41)	2.070 (38)	0.955 (42)	0.220 (6)
Musky II **(n)**	0.962 (48)	2.738 (48)	2.309 (49)	4.196 (22)	3.968 (45)	1.223 (38)	---	1.666 (31)	1.127 (42)	0.505 (4)
Grandon **(n)**	0.808 (34)	0.897 (34)	0.700 (35)	0.636 (31)	0.786 (33)	0.523 (31)	2.010 (33)	0.656 (34)	0.643 (34)	0.491 (12)

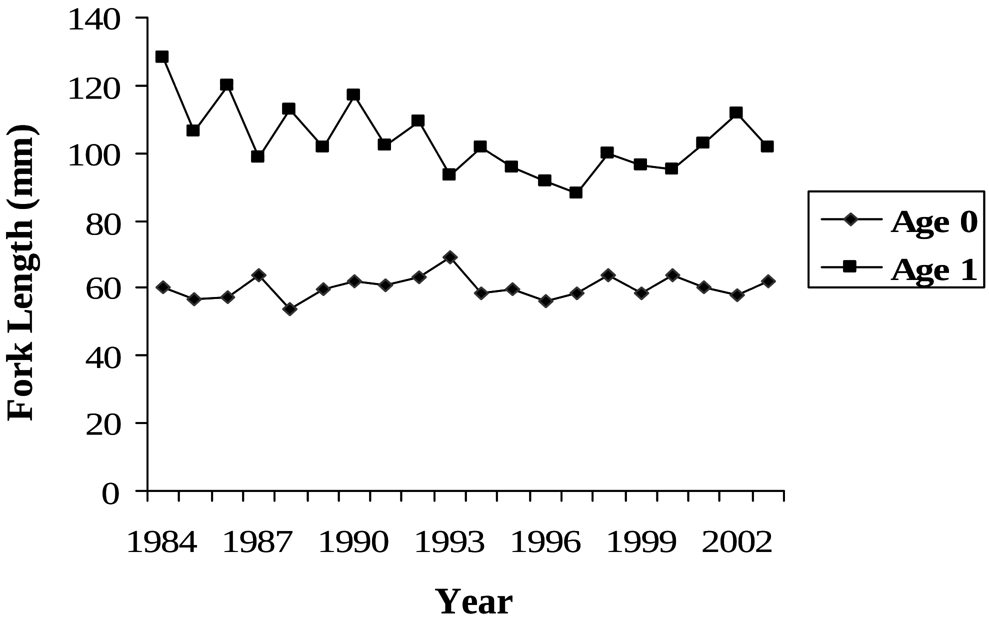

Figure 2.1 Mean fork length age 0 and age1 rainbow smelt from OMNR index trawl surveys in Long Point Bay, Lake Erie, October 1984 to 2003.

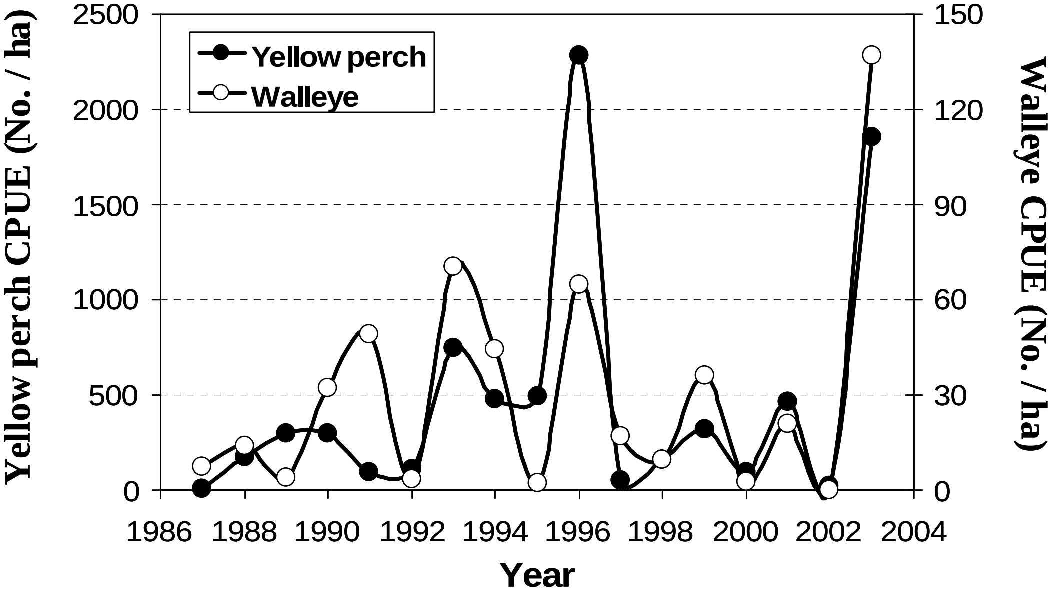

Figure 2.2 Catch per unit of effort (Number per hectare) of age-0 walleye and yellow perch in the western basin, Lake Erie, 1986-2003.

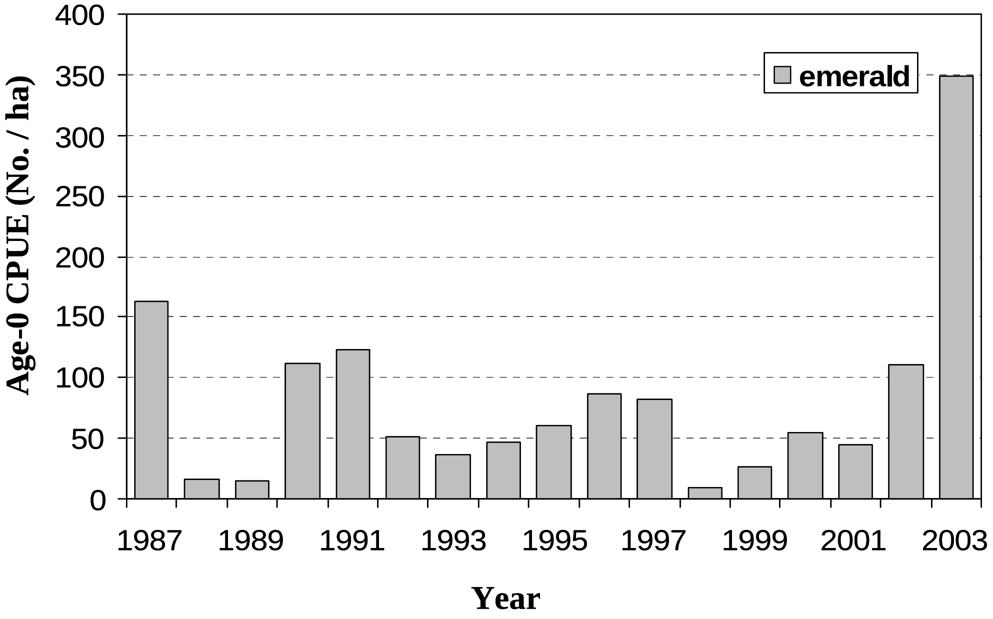

Figure 2.3 Emerald shiner age-0 CPUE from the western basin, Lake Erie, from 1987-2003

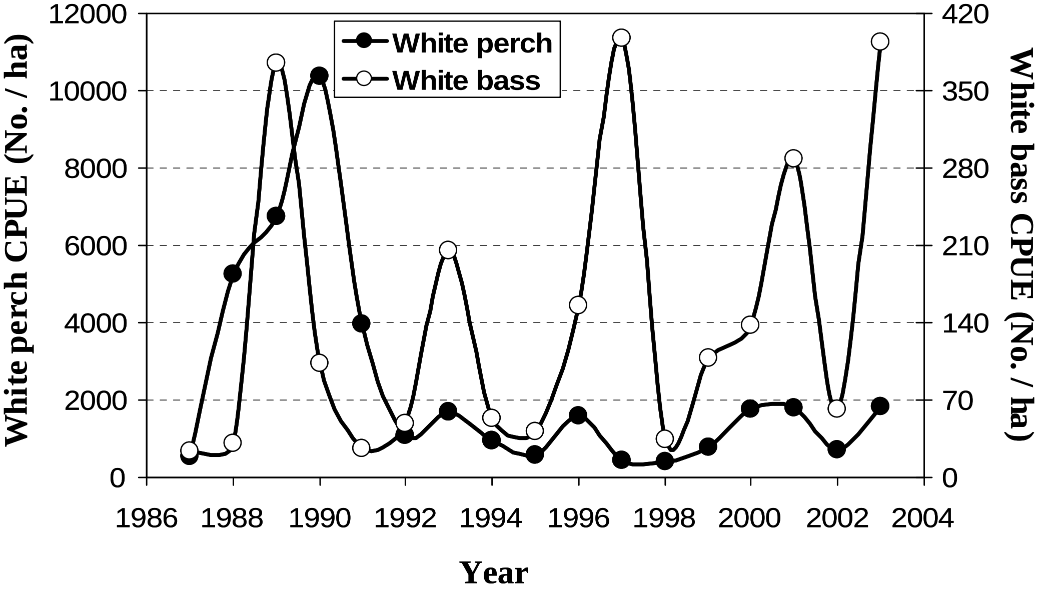

Figure 2.4 White bass and white perch age-0 CPUE in the western basin, Lake Erie, from 1986-2003.

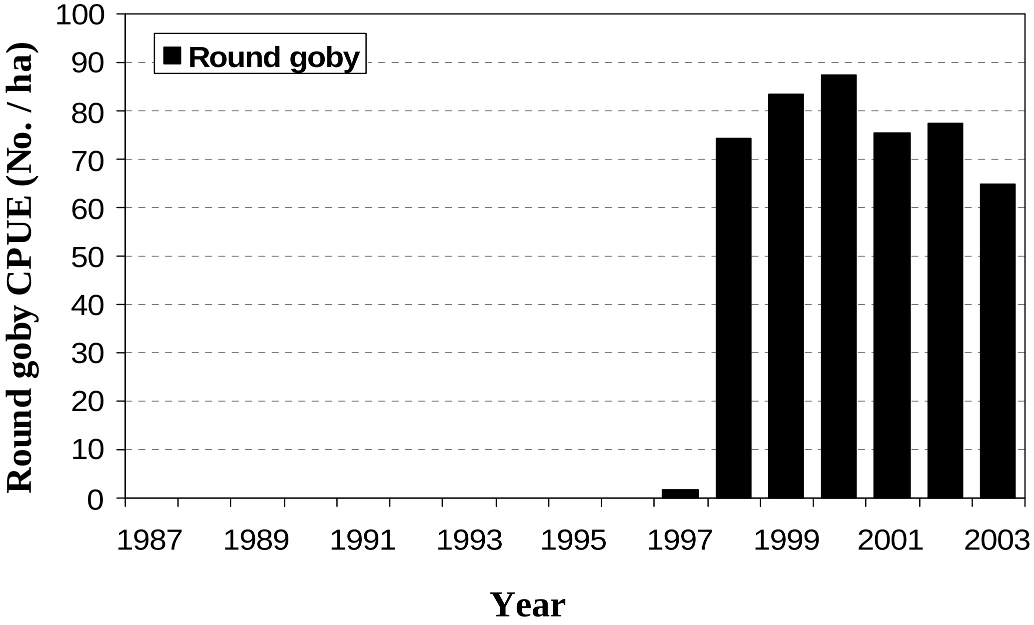

Figure 2.5 Round goby CPUE in the western basin, Lake Erie, from 1987-2003.

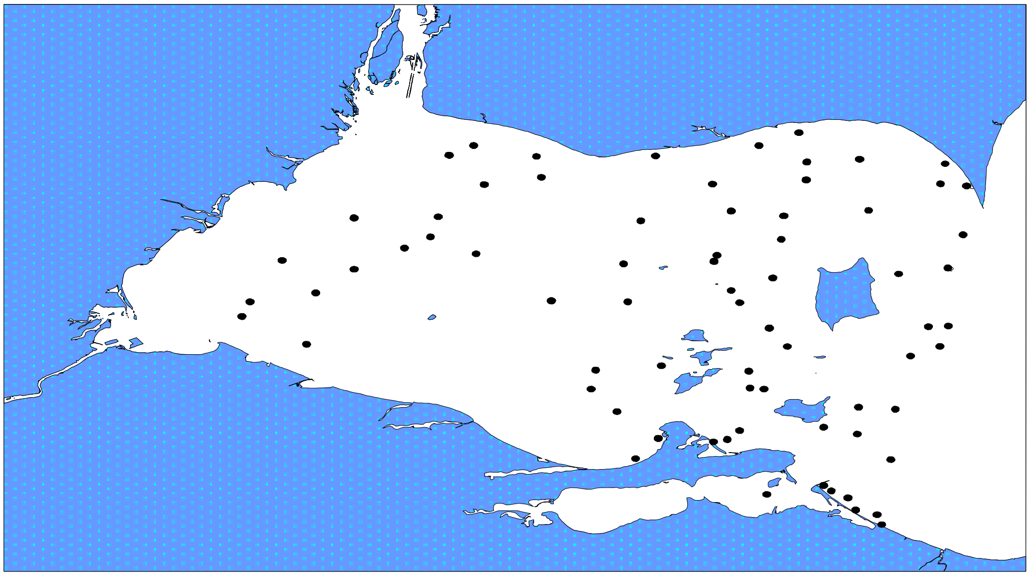

Figure 3.1. Trawl locations for western basin interagency trawl survey, August 2003.

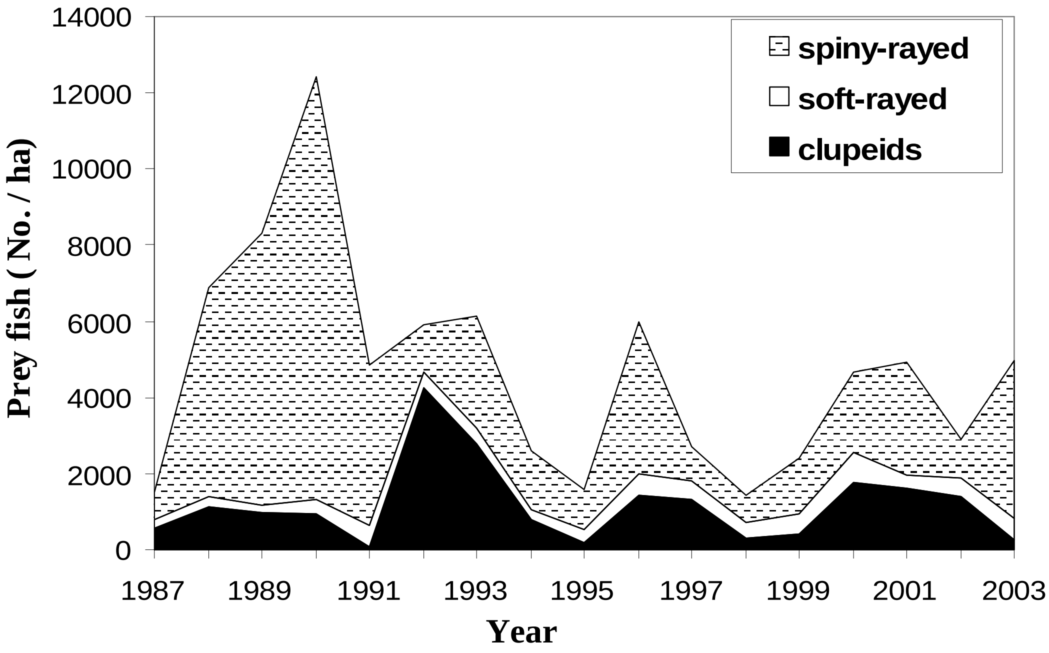

Figure 3.2. Mean density (no. / ha) of prey fish by functional group in western Lake Erie, August, 1987-2003.

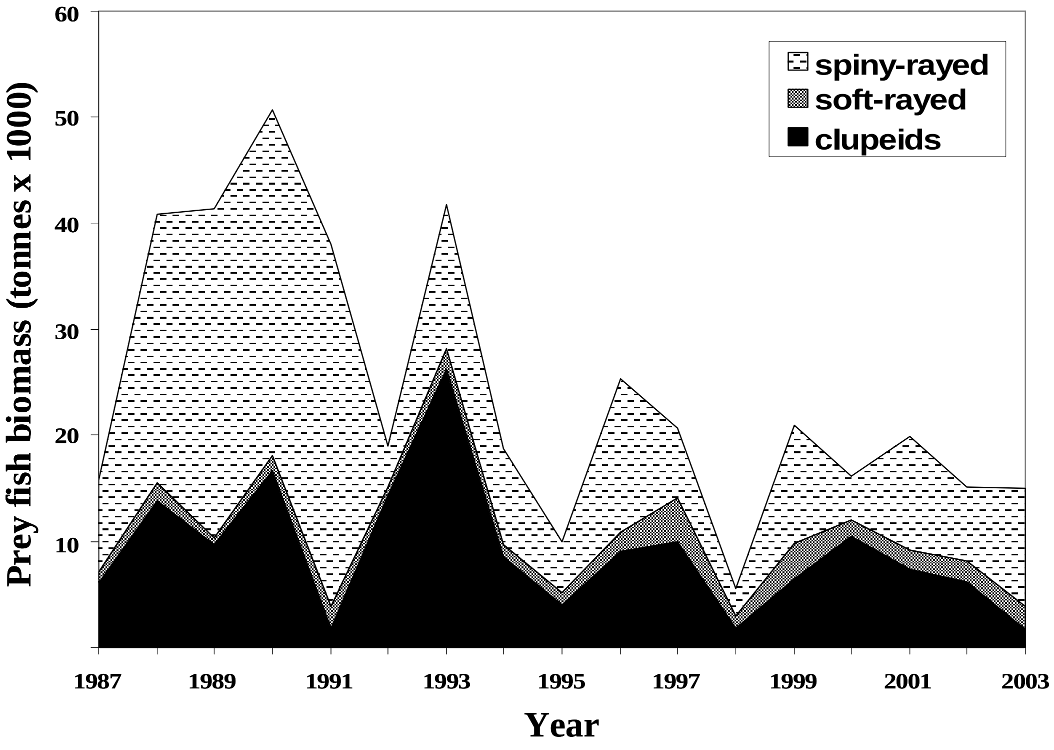

Figure 3.3. Mean biomass (tonnes) of prey fish by functional group in western Lake Erie, August, 1987-2003.

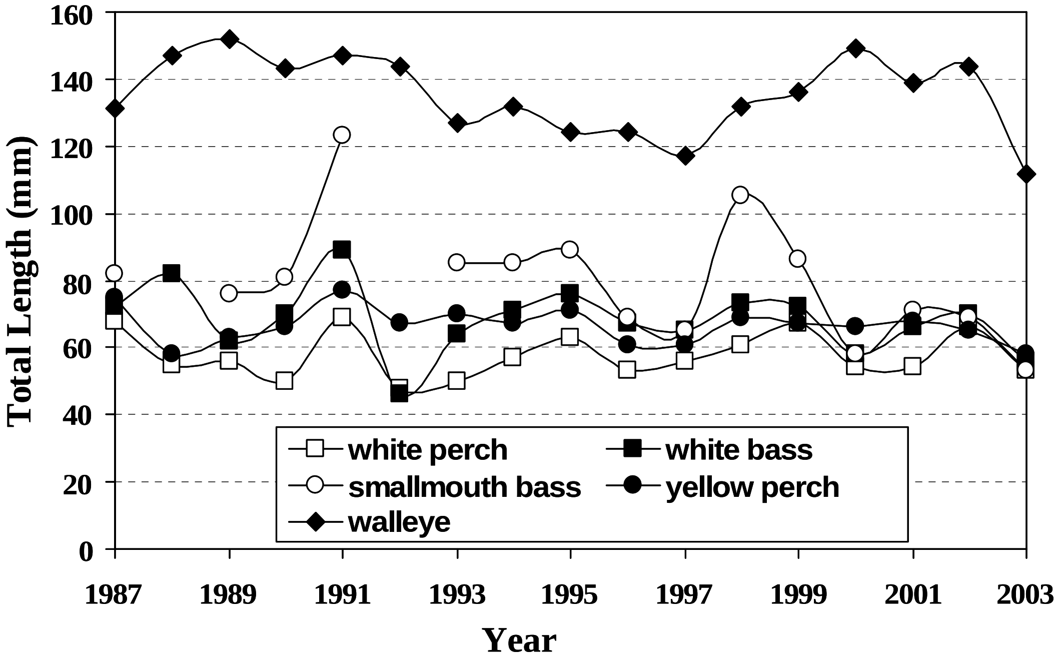

Figure 3.4. Mean total length (mm) of select age-0 fishes in western Lake Erie, August, 1987-2003.

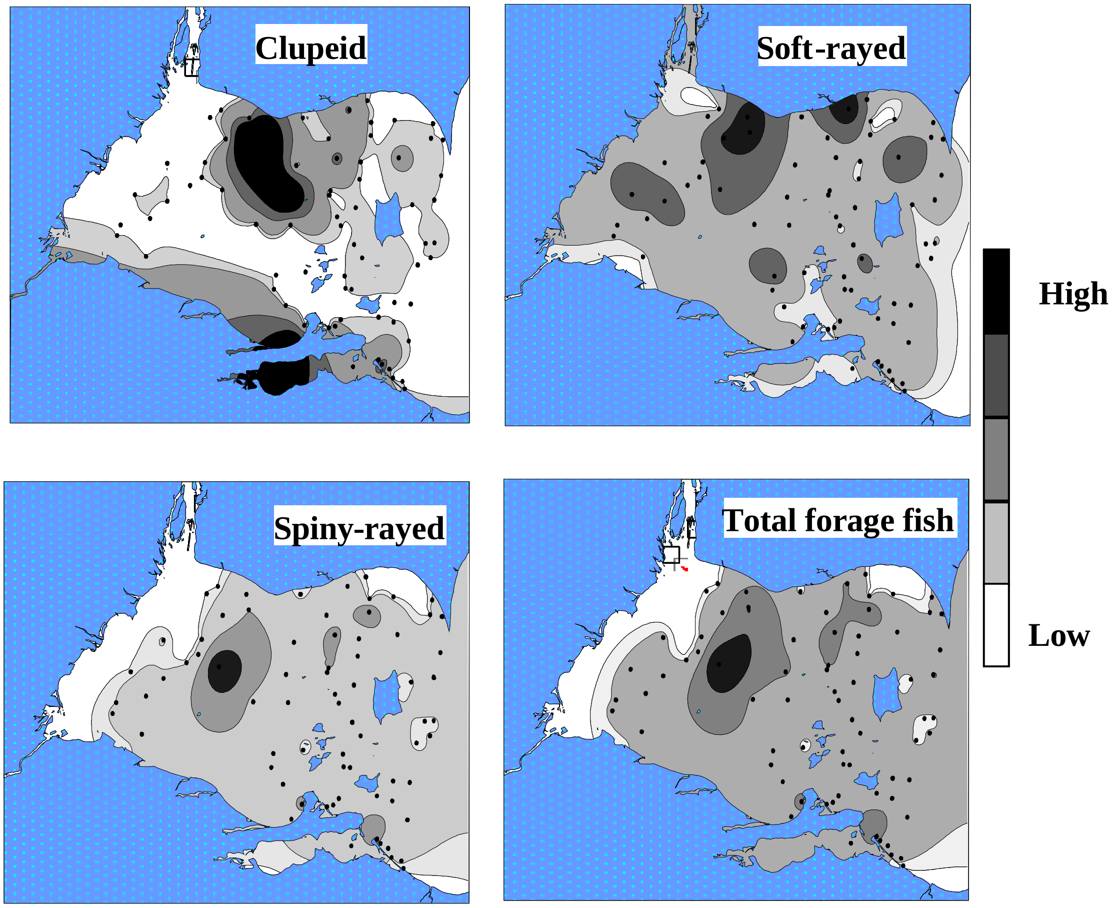

Figure 3.5. Spatial distribution of clupeids, soft-rayed forage, spiny-rayed forage, and total forage in western Lake Erie, August, 2003. Contour levels vary for each functional group.

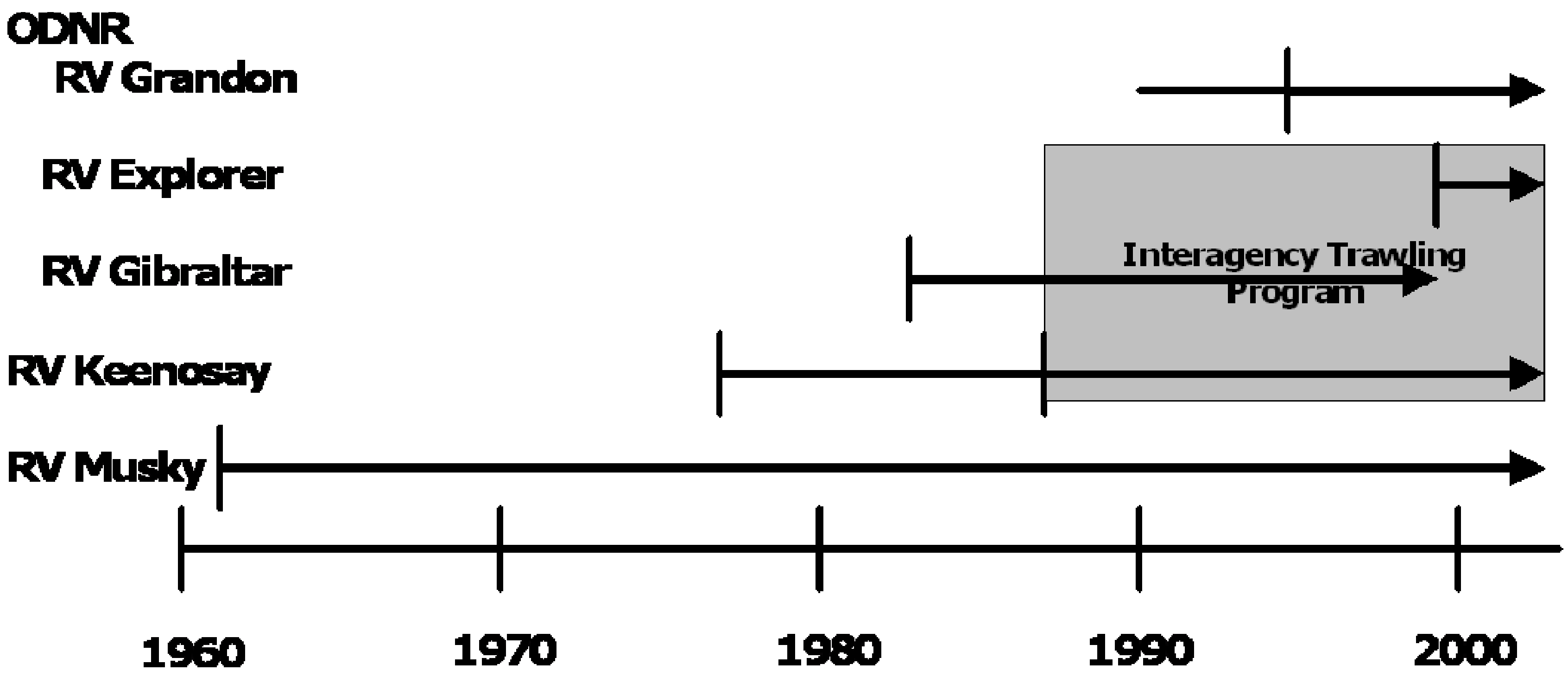

Figure 3.6. Timeline of trawling programs in the west and central basins of Lake Erie. Vertical lines represent years when either vessels or gear changed.

Figure 3.7. Spatial locations of current trawling stations in the west and central basins of Lake Erie, by agency.

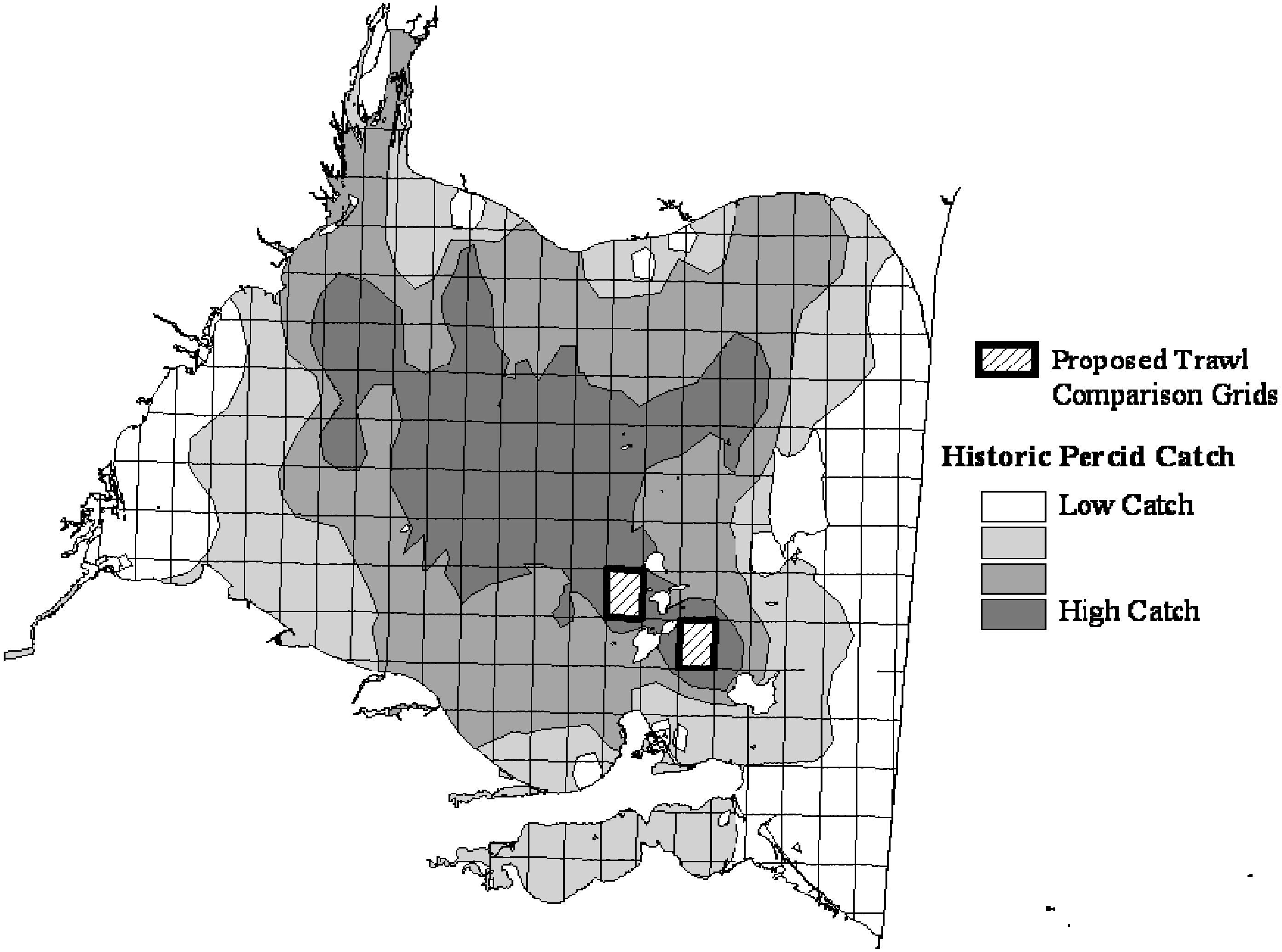

Figure 3.8 Spatial distribution of historic percid catches in the west basin of Lake Erie. Data are based on catches from the interagency trawling program, 1988-2001. Dark areas represent highest densities, while light areas represent low densities.

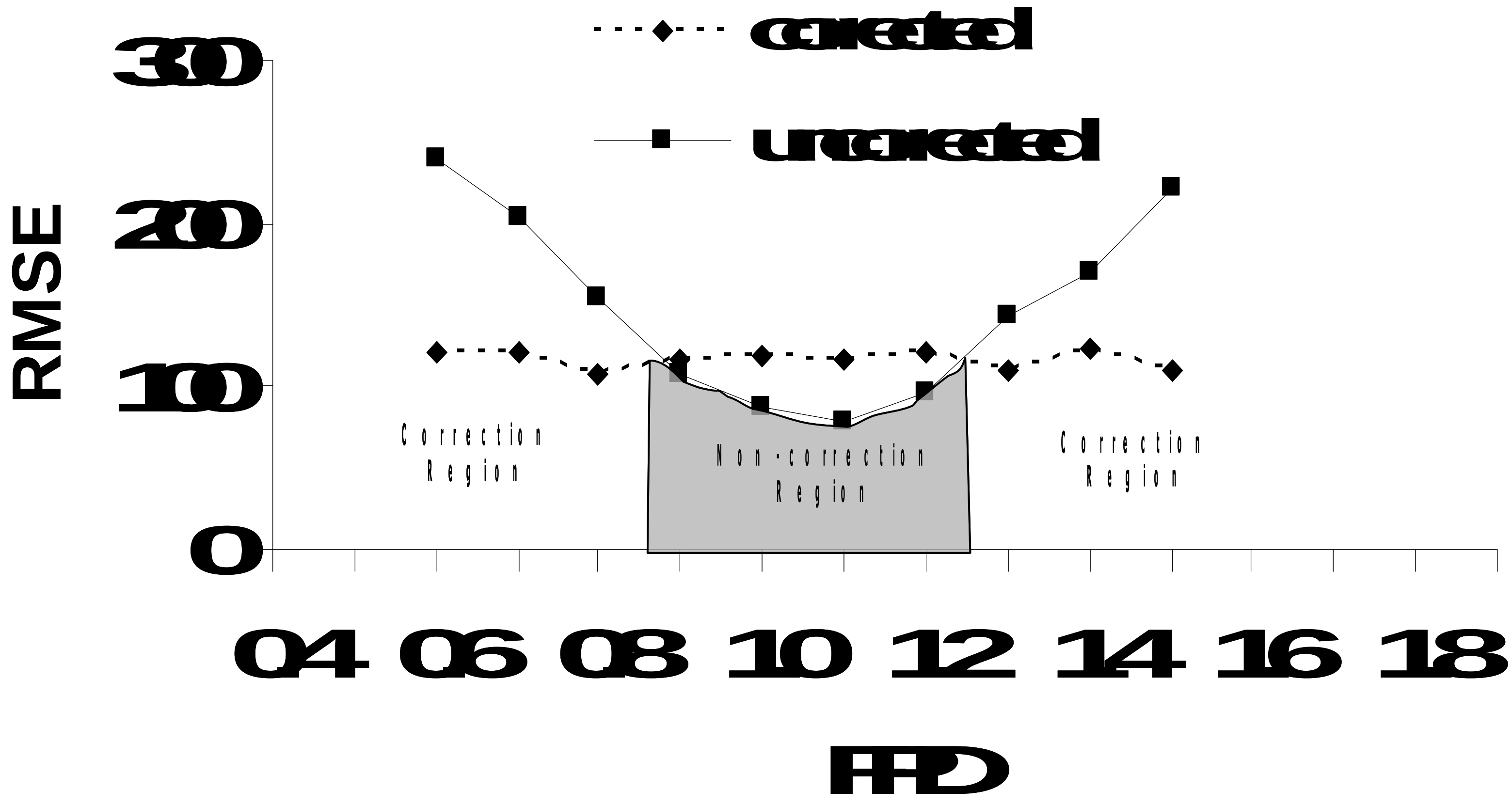

Figure 3.9. Mean Square Error (MSE) decision curve demonstrating non-correction region and correction region used as criteria for application of FPCs.

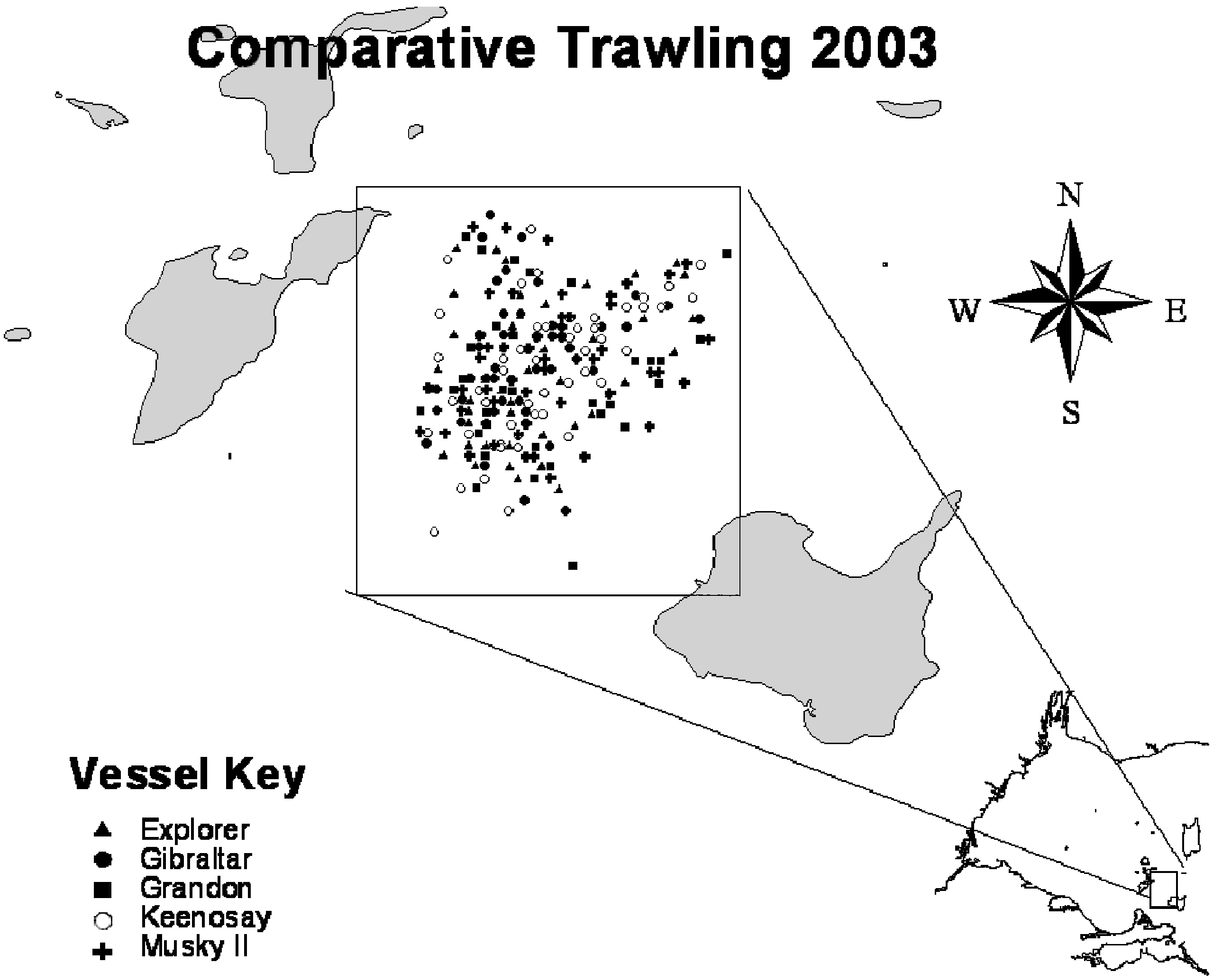

Figure 3.10. Study area for intercalibration experiment. Symbols represent vessel trawl locations during the experiment.

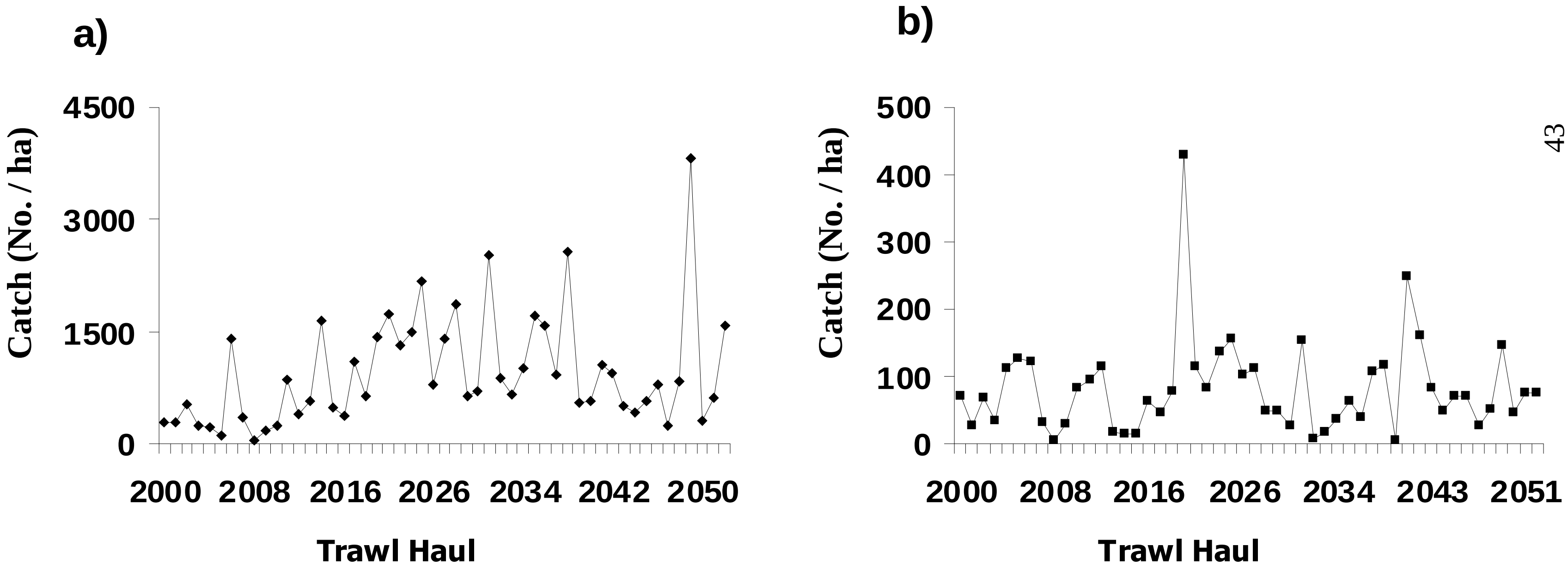

Figure 3.11. Catch (Number/hectare) of a) targeted (age-0 yellow perch) and b) non-targeted (troutperch) fishes by the standard vessel (RV Keenosay) by trawl haul.

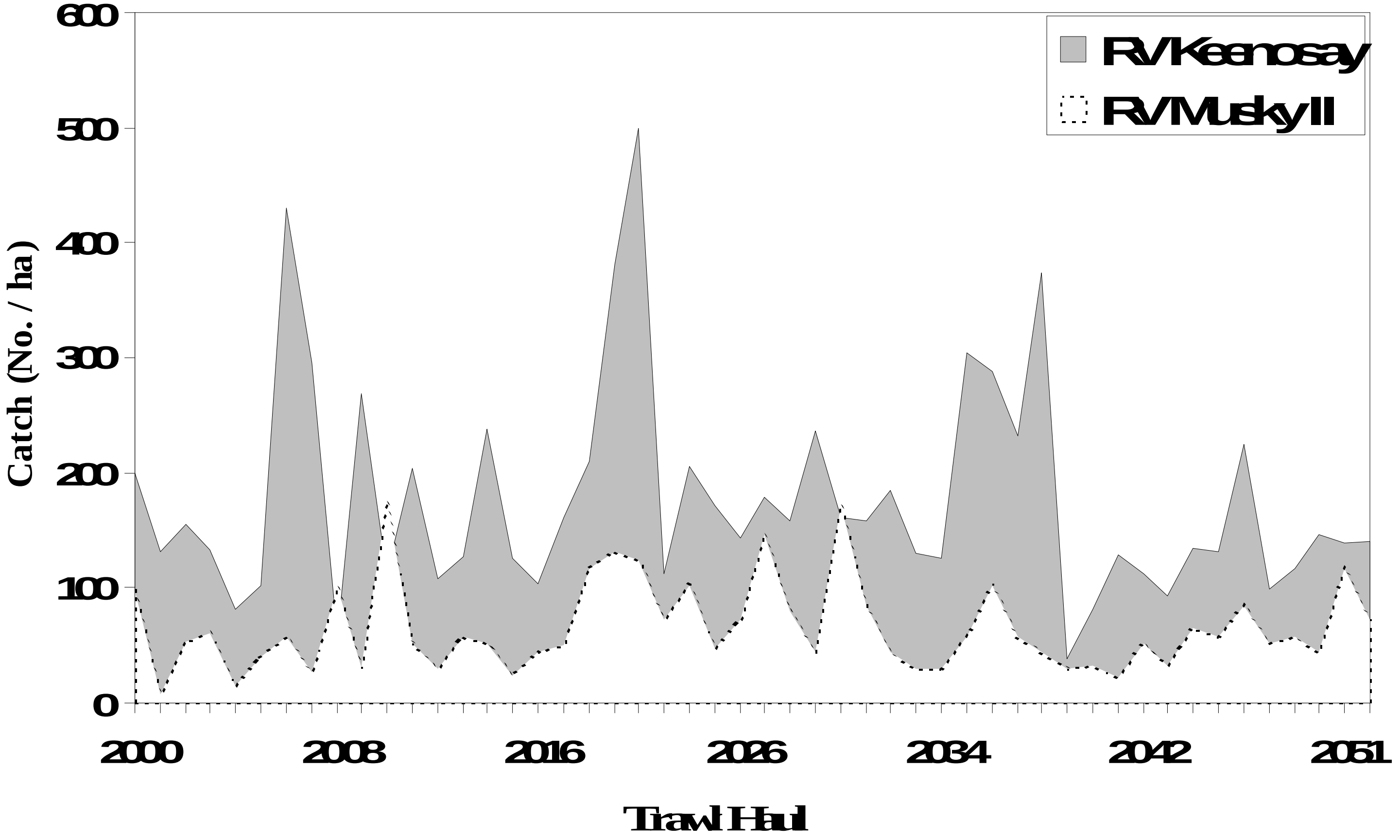

Figure 3.12. Raw CPUE data by trawl haul for age-0 walleye by the RV Keenosay and the RV Musky II. Gray area denotes systematic bias.

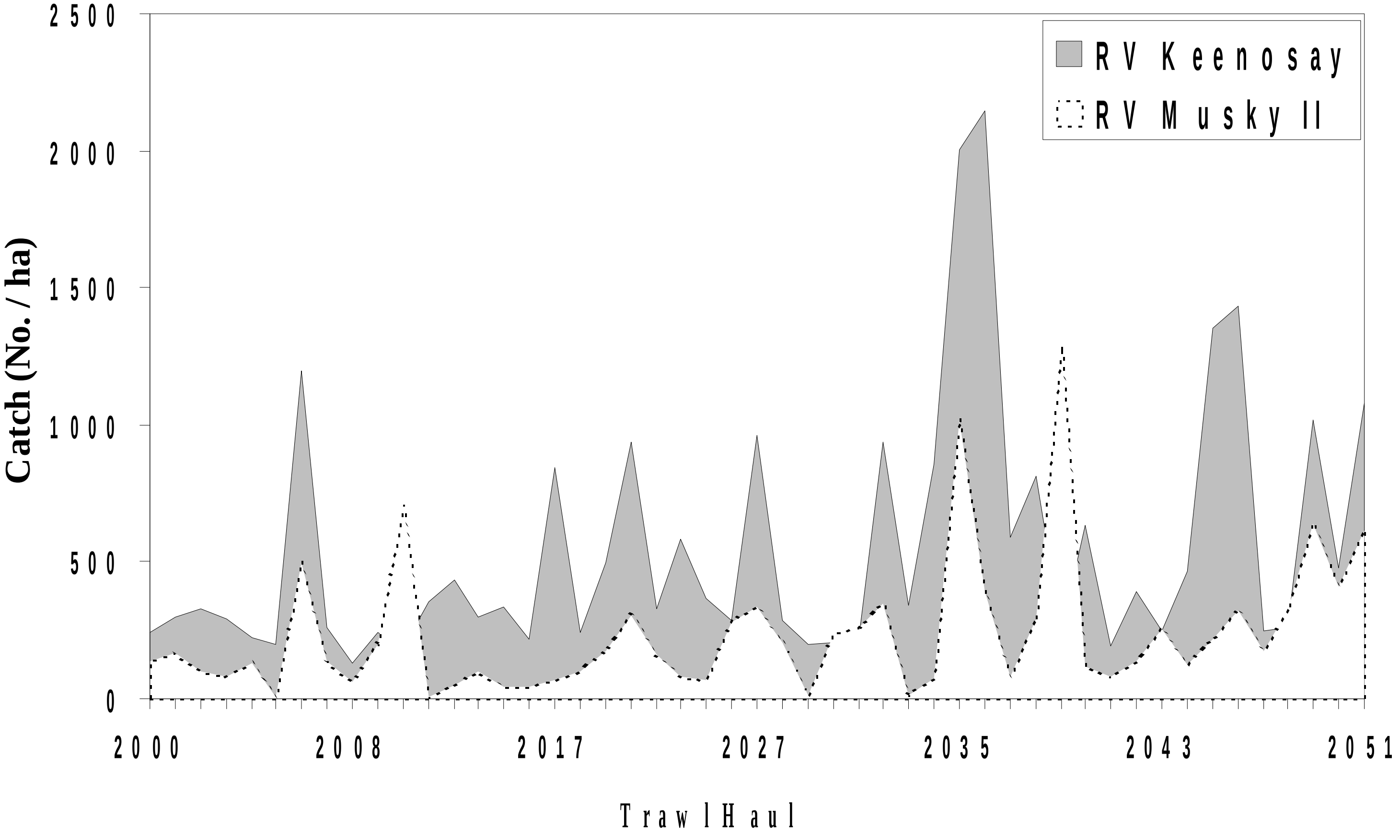

Figure 3.13. Raw CPUE data by trawl haul for age-0 white perch by the RV Keenosay and the RV Musky II. Gray area denotes systematic bias.

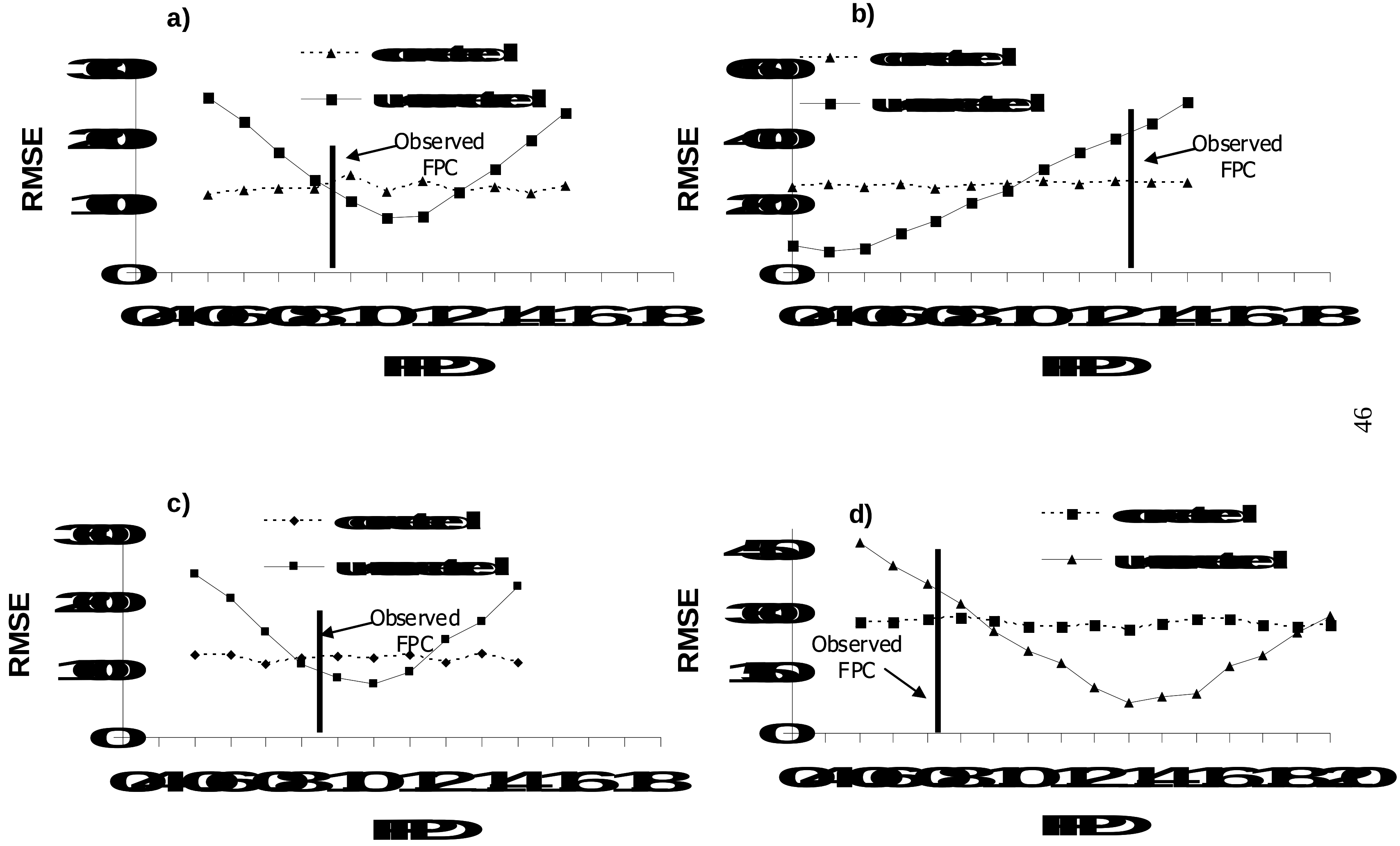

Figure 3.14. MSE decision curves for age-0 yellow perch for: a) RV Explorer; b) RV Gibraltar; c) RV Musky II; and d) RV Grandon over a range of imposed Fishing Power Differences. Heavy vertical line on graph indicates Observed Fishing Power Correction.

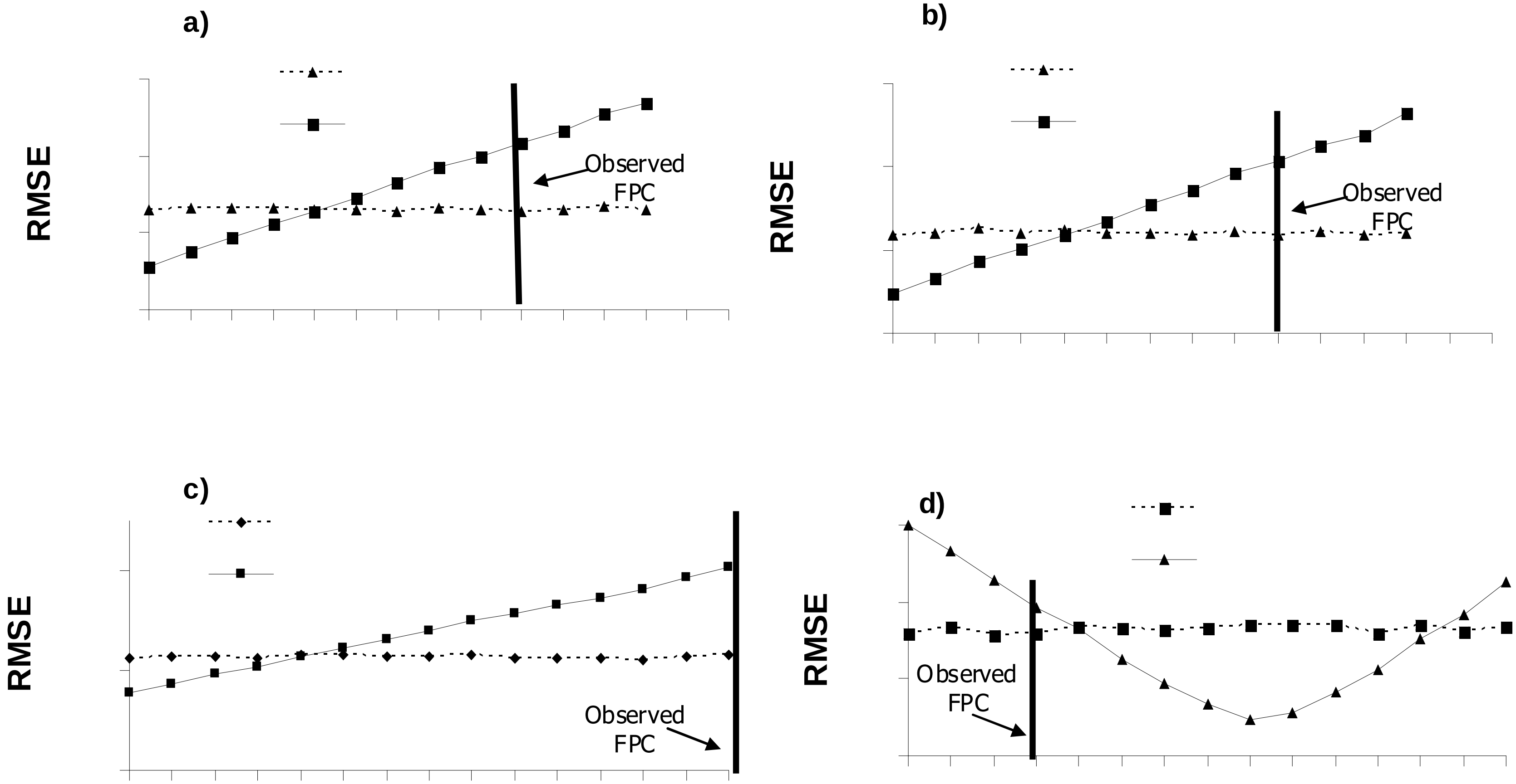

Figure 3.15. MSE decision curves for age-0 walleye for: a) RV Explorer; b) RV Gibraltar; c) RV Musky II; and d) RV Grandon over a range of imposed Fishing Power Differences. Heavy vertical line on graph indicates Observed Fishing Power Correction.

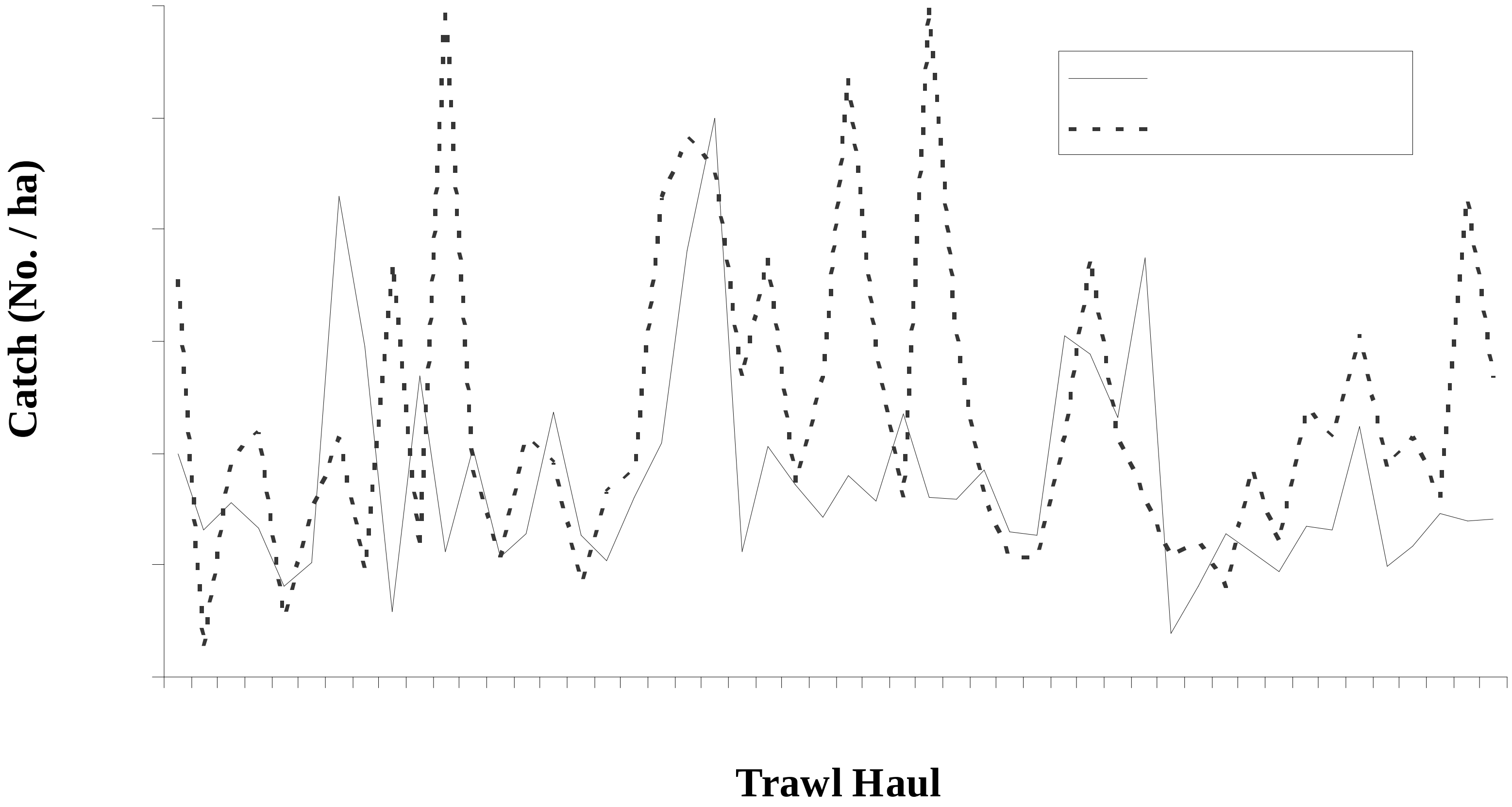

Figure 3.16. Result of application of FPC to Musky II CPUE data to standardize to RV Keenosay.

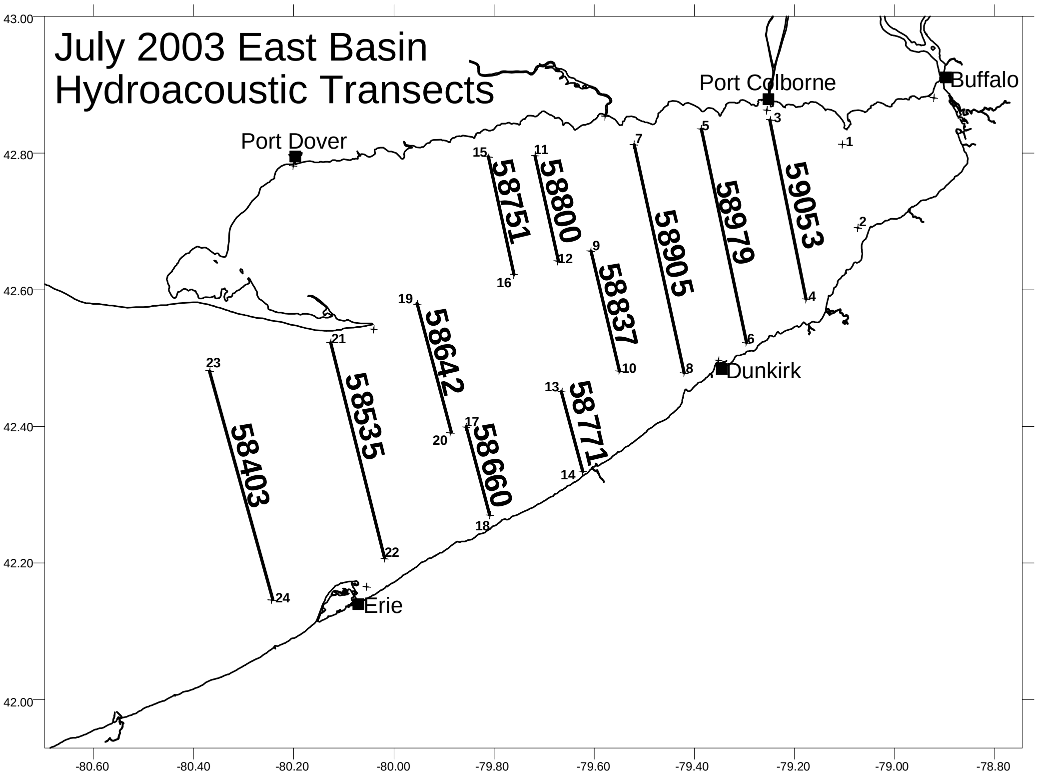

Figure 4.1. Sampling locations during the July, 2003 eastern basin fisheries acoustic survey.

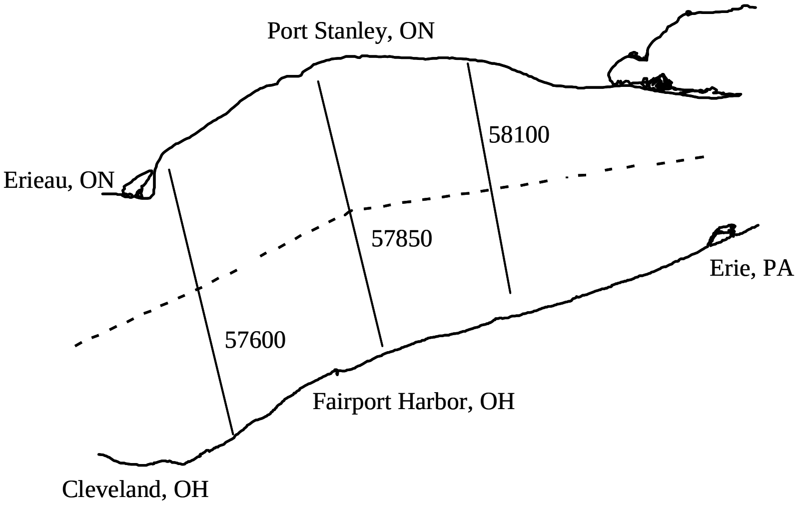

Figure 4.2. Acoustic transects central basin Lake Erie, July 29-August 1, 2003

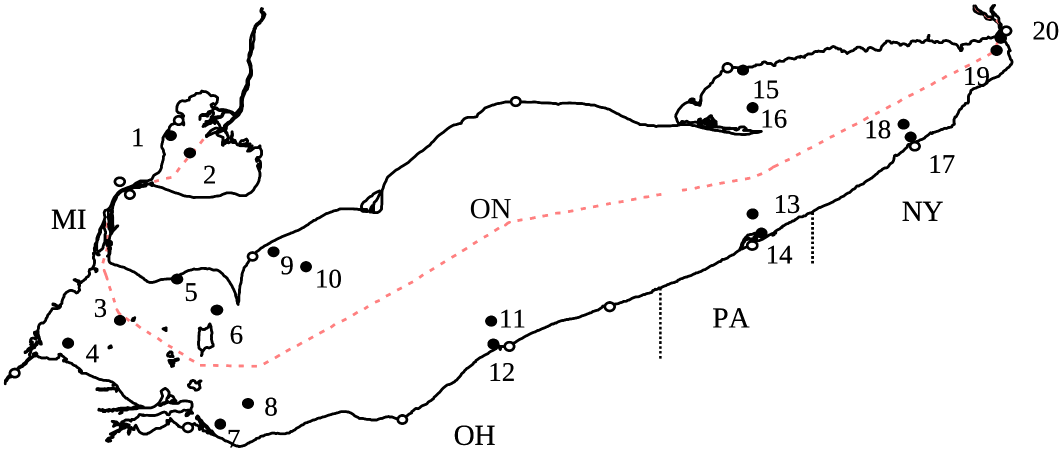

Figure 5.1. Lower trophic level sampling stations in Lakes Erie and St.Clair.

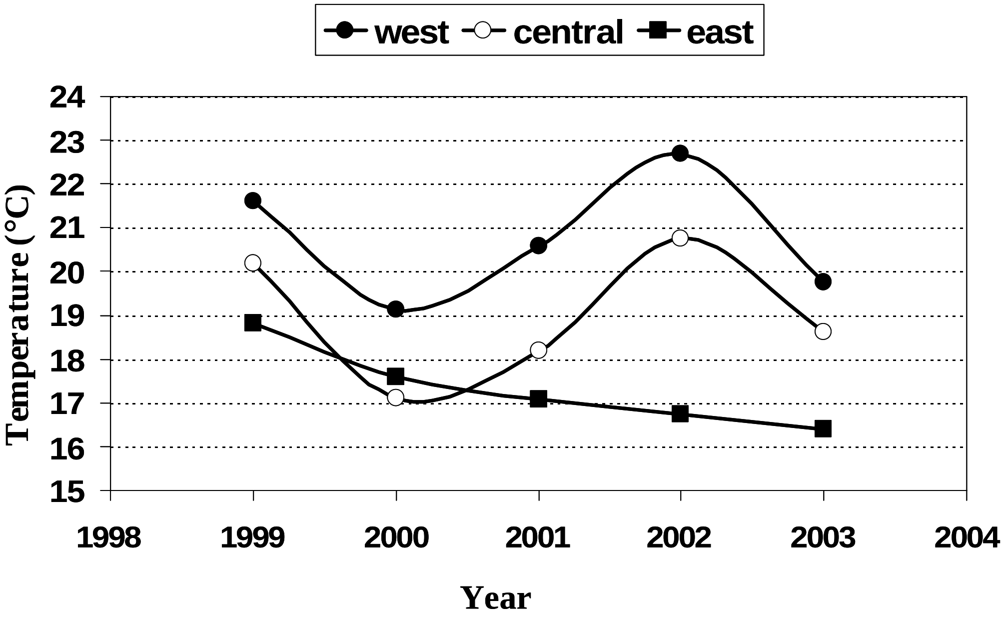

Figure 5.2. Average annual epilimnetic temperature (°C) by basin in Lake Erie, 1999-2003.

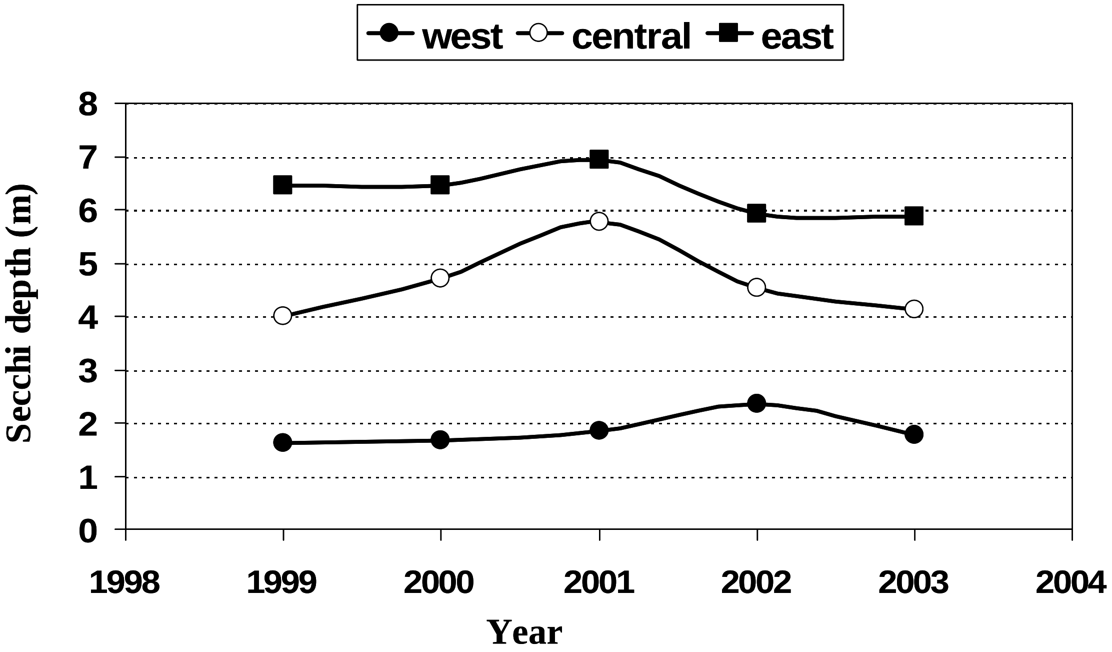

Figure 5.3. Average annual Secchi depth (m) by basin in Lake Erie, 1999-2003.

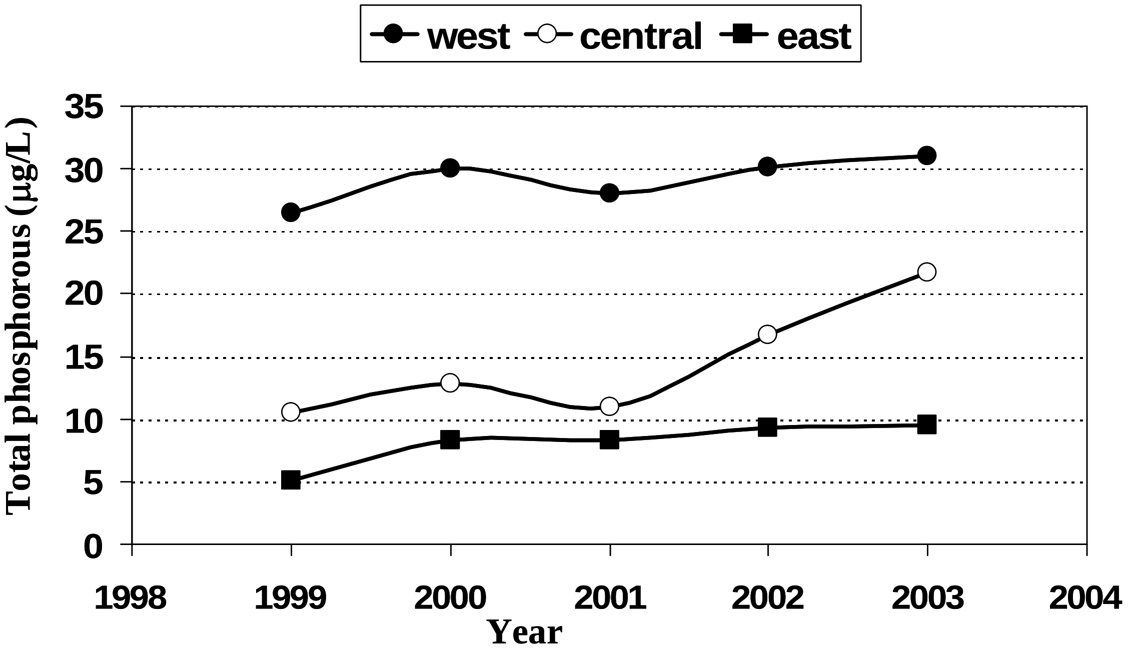

Figure 5.4. Average annual total phosphorus by basin in Lake Erie, 1999-2003.

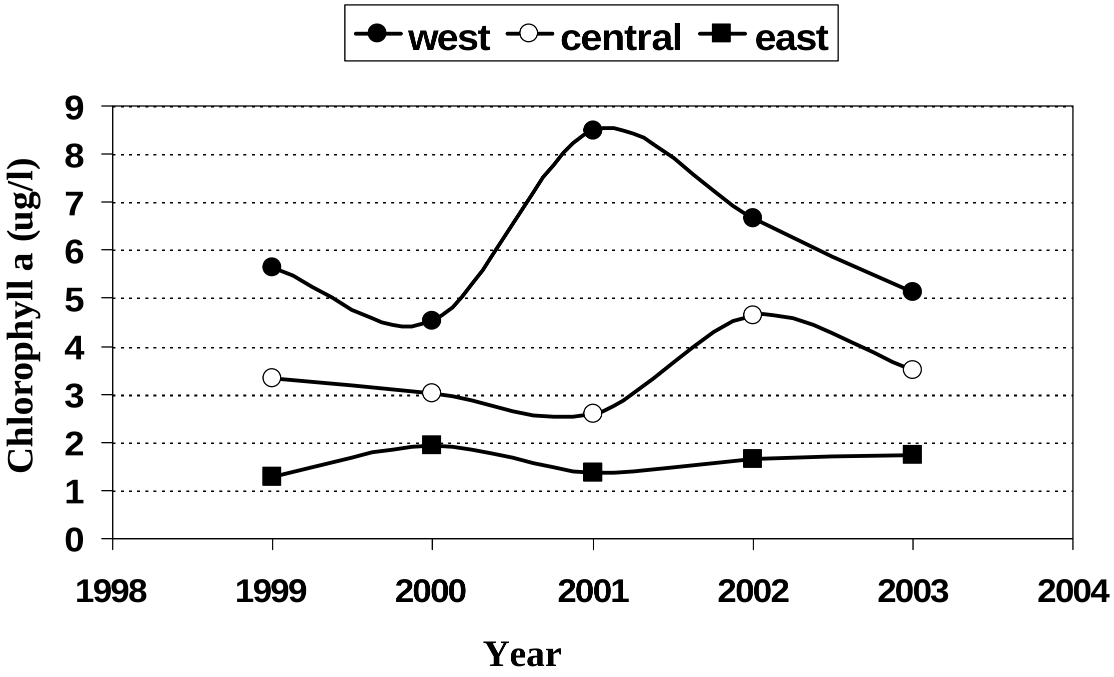

Figure 5.5. Average annual chlorophyll a by basin in Lake Erie, 1999-2003.

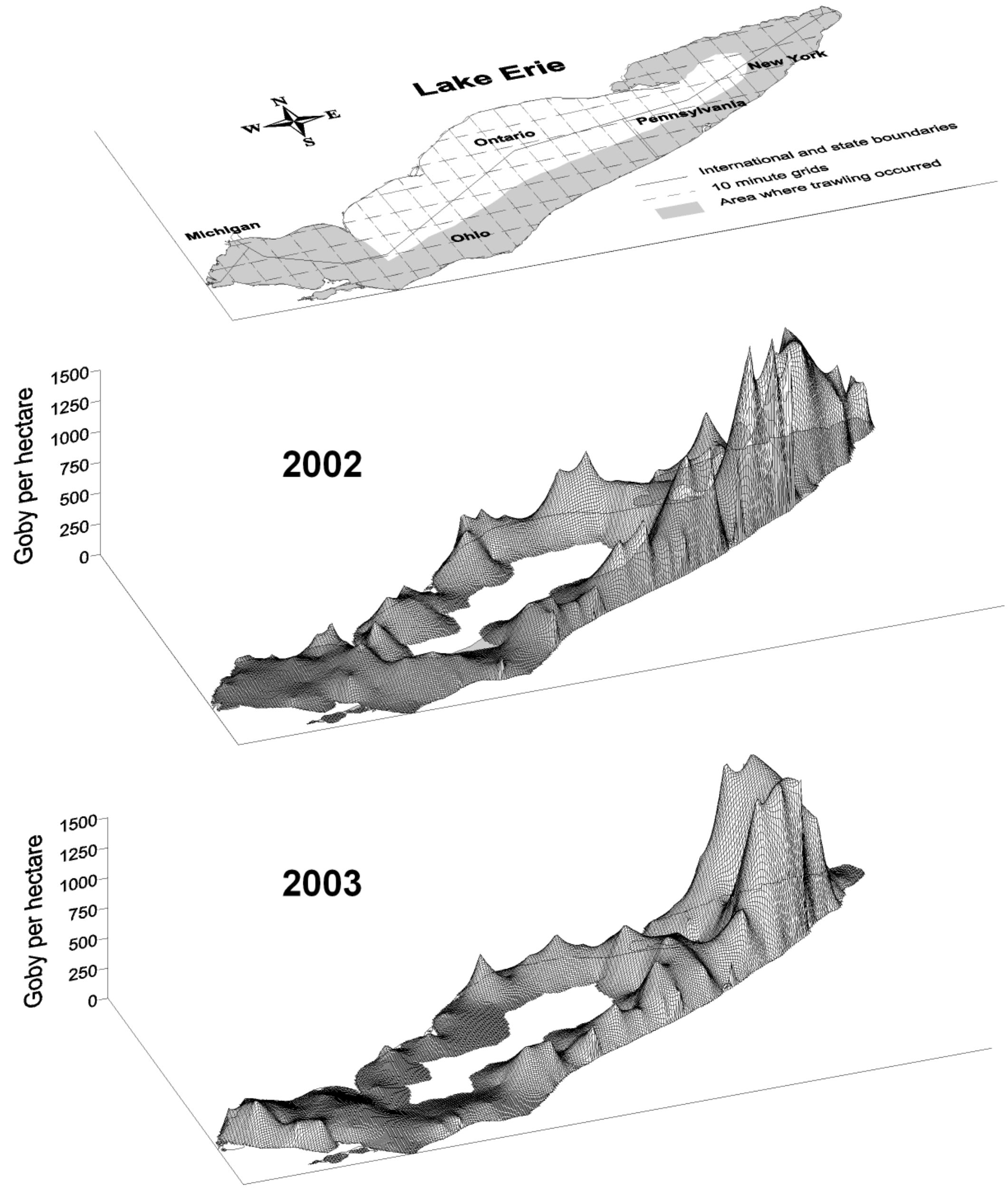

Figure 6.1 Two dimensional base map (upper) and three dimensional maps of round goby distribution in Lake Erie as density per hectare during 2002 and 2003 estimated from bottom trawl catches. The base map shows state and provincial boundaries, the ten minute grid system used for trawl data summarization, and the area of the lake sampled with bottom trawls (shaded gray). The goby distribution maps were extrapolated from individual bottom trawl catches averaged within 10 minute grids using SURFER© software and a kriging algorithm.