STUDY PERFORMANCE REPORT

State: Michigan | **Project No.:** F-81-R-7

Study No.: 230741 | **Title:** Towards comprehensive databases and coordinated surveys for ecosystem management in the Great Lakes

Period Covered: October 1, 2005 to September 30, 2006

Study Objective: The study has several objectives that relate to improving quality of data collected during fish surveys in Lake Huron: 1) Compile, integrate, and evaluate Lake Huron fish/habitat data sources. 2) Enhance the use of data available and quantify changes in fish community structure in their relation with to stressors such as invasive species, nutrient fluctuations, and key environmental conditions. 3) Evaluate coherence and connectivity between fish communities in Saginaw Bay and Lake Huron main basin.

Summary: During this second study period data from Saginaw Bay trawl and gill-net surveys were used to derive abundance indices for several forage fish species and for predators yellow perch *Perca flavescens* and walleye *Sander vitreus*. The effect of stressors on abundance was investigated. Also, data from the Lake Huron lake trout *Salvelinus namaycush* gill-net survey were analyzed to derive indices for forage species and lake trout.

The following data were analyzed for Jobs 2 to 5:

Saginaw Bay Fall Gill-net Surveys.–Data were from gill-net surveys conducted in fall since 1989. The survey is described in Fielder et al. 2002, and data available for this study were summarized in the previous Study Performance Report. General problems for analysis in the time series of data resulted from an increasing number of stations starting in 1993 and addition of a 38 mm mesh net in 1993. Further, catches from some sets were not recorded separately for the 38 mm panel. Given these shortcomings there are several options for analysis: 1) Select data after 1993; 2) Analyze all years of data (1989 to 2001) but excluding the 38 mm net catch; 3) Standardize 1989 to 1992 data to account for the missing 38 mm mesh panel. The first alternative precludes investigating the effect of zebra mussels that became established in 1991. The second alternative leaves out of the analysis more than half of the data recorded after 1993, corresponding mostly to small fish. The third alternative requires an analysis of 38 mm net selectivity.

Saginaw Bay Fall Trawl Surveys.–Data were from annual bottom trawl surveys, conducted in fall since 1989. Surveys are described in Fielder et al. 2002 and the information available to this study was summarized in the previous Study Performance Report. General problems to analyze in these data were the protocols to process the catch in early years, variation in number of tows and tow duration.

Lake Huron Gill-net Lake Trout Spring Surveys.–Data were from 403 gill-net sets of the Lake Huron trout gill-net surveys conducted from April to July 1975-2002 at fixed stations in Michigan waters of Lake Huron. Data were provided by researchers at Alpena Great Lakes Fisheries Research Station. Surveys were carried out on board RV Chinook. Surveys used 1.8 m deep nets of graded-mesh, multifilament gill nets. The standard gill-net set consisted of nine 30.48 m panels of 51 to 152 mm mesh in graded increments of 13 mm. General problems to analyze in these data are that the actual configuration varied, and the recorded length by set ranged from 274 to 3,018 m; thus gill nets contained 9 to 99 panels. The variation in set length poses a problem for analysis of abundance indices because depth covered by the nets also varied. For example, only nets of

3,018 m in length were deployed at depths greater than 50 m. Length also varied by station, where shorter nets were deployed in stations 1 and 2, and in most stations a combination of lengths was used. Further, the length of the gill-net gear varied by year. The 3,018 m net was used exclusively until 1985 and was discontinued after 1996, and from 1999 only the 549 to 1,372 m gill net was deployed. Another survey shortcoming is that the number of stations and survey design has changed since 1975. There was no single station sampled every year from 1975 to 2002. Stations 3, 4 and 10 were the stations more consistently sampled. During early years the effort was concentrated in northern areas, while in later years more effort has been allocated to stations in southern areas. The temporal distribution of sampling among stations poses difficulties for the analysis of annual trends in population abundance for the species caught in the gill-net survey. To account for changes in the survey distribution, indices were developed by station.

Findings: Jobs 2, 3, 4, 5, and 10 were scheduled for 2005-06, and progress is reported below.

Job 2. Title. Model variation in distribution and density of forage fish

Saginaw Bay Fall Gill-net Surveys

Total catch by set decreased from 1990 to 1995 and remained fairly constant until 2001. There were 34 species identified in all stations, and eight were present every year. Most abundant species excluding yellow perch and walleye were common white sucker *Catostomus commersoni*, channel catfish *Ictalurus punctatus*, freshwater drum *Aplodinotus grunniens*, white perch *Morone americana*, and gizzard shad *Dorosoma cepedianum*. Data from sets performed after 1993 were selected to model variation of forage fish abundance to exclude bias caused by the addition of 38 mm mesh panels. Excluding earlier years also, alleviates the problem of the number of stations expanding during the survey period. Generalized Linear Models GLMs (McCullagh and Nelder 1989) were used to derive indices, and included year and station as factor variables, and a poisson distribution. Annual GLM indices for white sucker decreased steadily from 1993 to 2001, those for catfish and drum increased, and those for white perch and shad fluctuated without a pattern. For all species, levels were higher in stations in the inner bay (2 to 7) than in stations in or close to the outer bay (8 to 11). For all species, levels within stations 2-6 and 9-11 were not significantly different.

Saginaw Bay Fall Trawl Surveys

There were 51 species identified in the trawl survey catch. About half of the species found in the trawl survey were not caught by the gill-net gear, while only 7 species (mostly salmonids) found gill-net catch were not present in the trawl. Fifteen species were caught every year. The catch was dominated by spottail shiner (22% of the total), trout perch (18%), rainbow smelt and alewife (15% each), white perch (14%), and yellow perch (10%). Generalized additive models GAMs (Hastie and Tibshirani 1990) were used to derive indices. Models included main effects variables year and Saginaw Bay quadrant as factors, tow time as a non-parametric smoother, and a poisson probability distribution. Alewife and smelt annual GAM indices fluctuated on a one to three year basis with no particular pattern and lowest levels were in 1990 and 1996 respectively. Trout perch GAM indices increased significant starting in 1992 and reached a peak in 1998, white perch indices dropped after a peak in 1989 to a minimum in 1993 and indices for spottail shiner remained stable. GAM indices for alewife and smelt were higher in quadrant 3 and 4 (and similar) than in quadrant 1 and 2 (also similar). Levels of trout perch and white perch were highest in quadrant 4 and 3 respectively, while spottail shiner levels were similar among all quadrants.

Lake Huron Gill-net Lake Trout Spring Surveys

Predominant species in the catch were lake trout, smelt, lake whitefish, burbot, round whitefish, alewife, and yellow perch. Largest catches were obtained in 1985 which corresponded to one of the years with more surface of nets deployed. To develop abundance indices, GLMs were implemented with year and station and the number of nets as variables and including a poisson distribution. Annual indices for smelt did not fluctuate significantly in the study period. No length distribution was available for years before 1996, but based on years of available data the mean size of smelt in the catch was around 140 mm, i.e. adult fish. Annual indices for alewife were highest in 1977 and otherwise fluctuated on an about 3 year cycle with lows in 1979, 1988 and after 1992. Based on years of available data the mean size of alewives was around 180 mm, thus age 3 and older.

Job 3. Title <u>Relationships of forage fish distribution and abundance with stressors.</u>–The main stressor in Saginaw Bay during the study period was the colonization by zebra mussels in 1991. Other potential stressors are changes in nutrient loadings and in temperature. We used a variety of data sets to characterize trends in physical environment in the Bay. These included (1) 1986-90 data on nutrient loading collected at the Saginaw River, (2) 1991-96 data from the NOAA/Great Lakes Environmental Research Laboratory Ecosystem (GLERL) Study of Saginaw Bay, and (3) water temperature from MDNR fish surveys starting in 1986.

Characteristics of the Saginaw bay gill-net survey were not conducive to analysis of the effect of stressors. Based on trawl surveys, patterns in annual abundance of trout perch were associated with a positive effect of zebra mussels, while other species showed no relationship. Also, there were several species that were caught in the trawl surveys only after 1991 when zebra mussel invaded the bay: ninespine stickleback, longnose sucker, silver redhorse, golden redhorse, mimic shiner, killifish, pugnose minnow, slimy sculpin, mottled sculpin, and muskellunge.

Total and soluble reactive phosphorus levels declined from 1974 to 1995 although levels peaked in 1981, 1985 and 1986. No abundance trends in forage species were found to be correlated with the decline, but species richness decreased with increasing phosphorus levels in years 1989 to 1995. The decrease was in terms of number of benthivores and pelagic species.

Job 4. Title: <u>Model variation in distribution and density of predators</u>

Saginaw Bay Fall Gill-net Surveys

<u>*Yellow Perch*</u>.–A shortcoming of the survey data to model distribution, abundance of yellow perch and to quantify relationships of distribution and abundance with stressors is that between 1989 and 1996 fish other that walleye were classified as bycatch, and these specimens were measured in inches rather than in millimeters, and scales for aging were not collected. This affects applying developed age length keys to assign ages. A total of 10,134 yellow perch were caught in the gill-net survey between 1989 and 2001. This number includes 2,542 recorded as bycatch. About 40% of the fish were aged and data were used to develop age length keys. To model abundance GLMs were used. The numbers of yellow perch caught per set were modeled as a function of main effects year and station and the poisson variance function was used to represent variability. Models were developed for the population and also for individual age groups.

<u>*All years of data available (1989 to 2001) excluding the 38 mm panel catch.*</u>–GLM results show a declining trend in population abundance starting abruptly in 1991 when zebra mussels colonized the bay. The trend continued until 2000 but the larger decrease was between 1990 and 1991, suggesting that this was not due to population change but rather to lower gill-net catchability caused by increased water clarity. Abundance varied among stations, with values above the mean

in stations 2 to 4 in the Saginaw Bay north quadrant, values around the mean in stations 5, 6, 7, and 8, in the west and south quadrants, and below the mean in stations in stations 9, 10 and 11 in the east quadrant and the outer bay.

Data after 1993 including data from the 38 mm mesh panel.–GLM results also show a decreasing trend in abundance, in this case starting in 1993, although less pronounced. The differences between all stations and stations 9, 10 and 11 are also observed, but indices in other stations are more similar.

All years of data corrected for selectivity of the 38 mm mesh size- Indices by age.–The 38 mm mesh size panel mostly selected yellow perch less than 20 cm in length. The density of the size distribution of fish caught in the 38 mm panel peaked at 15 cm while the density in the larger mesh panels peaks at 20 cm. Age structure of the catch in the 38 mm mesh panel consisted of about 50 % age 2 and 25% ages 1 and 3 fish, while catch in larger mesh size panels was dominated by older fish ages 4 (31%), 3 and 5 (about 20% each). GLM indices for ages 1 to 6 yellow perch adjusted for the addition of the 38 mm (not show) decreased significantly from 1990 to 1992. Further, indices also show a general increase in 1993. Since indices from all cohorts were affected simultaneously, is it likely that the decrease does not appropriately represent trends in abundance. In space, levels were significantly lower in the outer bay than in the inner bay for fish up to 4 years old. Results indicate that the distribution of yellow perch within the inner bay and the outer bay is fairly homogenous among stations covered by the survey. This finding has implications for survey design.

Walleye.–A total of 3,675 walleye were caught from 1989 to 2001 in 166 of 175 standard gill-net sets. Only 47 fish were caught in the added 38 mm mesh size panel. Thus, the analysis was not affected by the panel addition in the survey as it was for yellow perch. Also, walleye were not processed as bycatch and were all aged, thus the difficulties in assigning ages based on age length keys for the yellow perch analysis did not apply.

To estimate walleye population abundance indices and indices by age, GLMs were used where numbers caught by set were modeled as a function of variables year and stations as factors, and variation was represented by a poisson distribution. GLM population indices show an important drop and a steady decline in abundance starting in 1992. The sharp 1991 decrease observed for yellow perch was not evident. Levels were generally higher in inner bay stations, except for station 4, than in stations close to or in the outer bay.

GLM indices for walleye ages 1 to 6 decreased starting in 1992. Age 1 indices were highest in 1990 and 1991 and fluctuated thereafter with lows in 1994 and 1997; age 2 and 3 indices lagged one and two years behind, and for older ages the decrease was gradual and steady. Levels were fairly similar among stations although lower in station 4 for all ages.

Saginaw Bay Fall Trawl Surveys

Yellow Perch.–There were 128,984 yellow perch caught in the Saginaw Bay fall trawl surveys between 1987 and 2001. Protocols used in earlier years precluded obtaining a complete description of the catch size-age structure for the time series so this analysis was for total population.

I used GAMs to estimate indices of yellow perch population abundance. Numbers by tow were modeled as a function of year and quadrant as factor variables, and tow duration (2 to 20 min) introduced as a non-parametric smoother. A poisson variance function was used. GAM indices decreased from 1989 to 1994 and partially recovered. Levels did not decrease sharply from 1990 to 1991 as was observed for indices derived from the gill-net survey. Otherwise patterns resemble gill-net based indices for age 1 and 2 walleye, which is fitting since the age structure of the trawl catch is dominated by young fish.

Walleye.–Walleye were scarce in trawl catches; nevertheless trawl survey data were used to derive abundance indices for comparison with those derived from gill-net survey data. A total of 1,339 walleye were caught in 349 of the 578 trawl hauls. The percentage of the tows that caught at least one walleye ranged from about 40% to over 90% depending on the year.

GAMs were run to derive indices for numbers caught by tow modeled as a function of year and Saginaw Bay quadrant as factor variables and tow time as a nonparametric smoother. The model included a poisson distribution. Results show peaks in 1991, 1998, and 1999, similar to indices derived from gill-net surveys for ages 1 / 2. Levels were lowest among tows conducted in quadrant 1 in the east and south of Saginaw bay, coinciding with levels in gill-net stations 8, 9 and 10. The age structure of the catch was dominated by ages 0 to 2, and in 1991 the proportions were evenly distributed among these ages while in 1998 and 1999 catch was dominated by age 0 and 1 fish respectively.

Lake Huron Gill-net Lake Trout Spring Surveys

Lake trout.–Data were evaluated from 34,841 lake trout collected from stations 3, 4 and 10, the stations more consistently sampled. GLMs incorporating year and depth as factor variables and a poisson distribution were used to develop annual indices for ages 3 to 6. Subsets of data were used to investigate the consequences of changes in gear characteristics. GLM annual indices varied by station: in station 10, indices tended to decrease until 1991 and bounced in later years with highest levels at the end of the time series; in station 4, levels tended to increase until 1986 and remained stable there after; in station 3 two cycles with peaks around the mid eighties and mid nineties were observed.

Job 5. Title: Quantify relationships of predator distribution and abundance with stressors.–The limited extent of the time series and bias of the gear did not allow for exploring relationships of fish abundance and stressors based on the Saginaw Bay gill-net survey.

Based on Saginaw Bay trawl survey, no relationship was found in trends in abundance or distribution of yellow perch or walleye and zebra mussel invasion or decrease in phosphorus levels. Nevertheless, the decreasing trends in yellow perch and walleye abundance between 1990 and 1995 suggest that an initial negative effect could have occurred.

Job 10. Title: Write progress report.–This progress report has been prepared.

Literature Cited:

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