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Fisheries of Saginaw Bay, Lake Huron 1986-2010

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Abstract.- Saginaw Bay, Lake Huron supports both recreational and commercial fisheries. The recreational component is comprised of sport anglers and a charter industry. The commercial fishery is a state-licensed fishery (mostly trapnets) and a bait harvest industry (mostly seining). Walleye and yellow perch are the primary target of the recreational fisheries while yellow perch and lake whitefish are the primary target of the commercial fishery. Emerald and spottail shiners along with juvenile suckers are the primary target of the bait harvest industry. From 1986 – 2010, annual recreational walleye harvest (numbers, sport and charter combined) ranged from a low of 49,878 to a high of 317,050, fueled in recent years by recovery of a naturally reproducing walleye population. During the same period, recreational harvest in numbers of yellow perch declined from a high of 5,610,835 to 195,886. Similarly, the

commercial yield of yellow perch is estimated to have declined from a high of 120,863 kg to a low of 17,230 kg. Commercial yield of lake whitefish has been greater in recent years, ranging from a low of 188,713 kg to a high of 666,218 kg. In addition, the commercial fishery results in a by-kill of walleye and lake trout amounting to 21,500 walleyes between May and August in 2010. Only three years of bait harvest reporting are available but that industry's annual harvest was has been as high as 60,627 liters. In all, it is estimated that the collective fisheries of Saginaw Bay may annually harvest as many as 22 million fish.

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Introduction

Accurate measures of the magnitude of extractions are fundamental to the management of any fishery. Such measures or estimates are indicators of effects of management efforts and gauges of system stressors. They signal changes in abundance and species composition, are gauges of effects of invasive species and are integral components of quantitative fishery assessment and subsequent modeling efforts. Statistics representing fisheries can come o the form of direct reporting or through estimation procedures. The form they take often depends on the type of fishery (e.g. commercial vs. recreational). Such is the case with Saginaw Bay, a productive region of Lake Huron, where a large variety of extractions take place, spanning many species.

Saginaw Bay's fish community and fisheries have experienced enormous change since record keeping began in the late 1800s. The early Saginaw Bay fishery was characterized by unbridled commercial exploitation. The fishery greatly expanded from 1912 to 1940, accounting for 28% of all the commercial yield of Lake Huron (Baldwin and Saalfeld 1962). Saginaw Bay produced the second largest walleye (See Appendix 1 for a listing of all the common and scientific names of fishes mentioned in this report) fishery in the Great Lakes (Schneider and Leach 1977). The commercial yield of many species was largely sustained until the mid-1940s but vacillated, likely reflecting periods of overfishing and recovery. Historically important commercially extracted species included lake trout, lake whitefish, cisco, walleye, yellow perch, sucker spp., carp, catfish spp. and others (Hile and Buettner 1959).

From the mid-1940s through the early 1970s, Saginaw Bay was in a highly degraded state. The decline of the fishery was probably fueled more by degradation of habitat and water quality than by overexploitation (Schneider 1977; Schneider and Leach 1979). Moreover, simultaneous with habitat degradation, was the invasion of several nonnative species including alewives (Eshenroder and Burnham-Curtis 1999). Suckers and carp also increased (Hile and Buettner 1959). Yellow perch remained as the only commercially marketable population during this time period. Coinciding with these fishery declines in the bay, sea lamprey became established in Lake Huron, further decimating a variety of fish populations (Leach et al. 1999). The commercial fishery for walleye was formally closed in 1970 but had not been viable for at least two decades prior to that.

By 1961, commercial fishing activity in Lake Huron was increasingly concentrated in Saginaw Bay and focused primarily on yellow perch, lake whitefish, channel catfish and some rough fish species (Baldwin and Saalfeld 1962). In 1968, the Michigan Department of Natural Resources (DNR) utilized newly granted statutory authority to institute a "limited entry" policy which effectively capped the number of licenses to those fishing operations the Department considered "full time" over the previous three years. The policy prevented new entries unless the interested party could find a current licensee willing to sell their share in the fishery. While allowing the Department to limit the number of licenses in the fishery, the same statute also protected any license that had been deemed a full-time fishery in 1968 from further attempts to restrict the total number of licenses in the future. Limited entry had an immediate effect on effort and harvest. By 1971, only 58 commercial fishing licenses were issued for Lake Huron (down from 318 licensees just a decade before) with 47 in inner Saginaw Bay. The combined harvest was trimmed to 1,276,863 kg from 3,137,952 kg a decade before, with lake whitefish, yellow perch, channel catfish, and carp constituting 90% of the total.

The 1970s to 2004 was a period of slow recovery. It began with the passage of the Clean Water Act and the Great Lakes Water Quality Agreement of the early 1970s. The DNR initiated a program of walleye fingerling stocking with the goal of reestablishing a viable predator population and fishery (Keller et al. 1987). By the early 1980s, a substantial recreational fishery had developed for walleye. Management emphasis for the recovering walleye population was focused entirely on developing the recreational fishery, as the commercial walleye fishery remained closed. By 1981, the number of Lake Huron

commercial fishery licenses had decreased to 36, with nearly all of the reduction attributed to Saginaw Bay. Even with this substantial decrease in licenses issued, because of improvements in commercial gear, total harvest remained constant at about 1,179,340 kg with whitefish, yellow perch, channel catfish, and carp still constituting about 90% of the total.

Recreational fisheries management focused on harvest regulation using length and daily possession limits and, in the case of walleye, a closed season in spawning tributaries. For most of the reporting period (1986 – 2010), recreational harvest of walleye was limited to those at least 381 mm in total length, intended to allow for maturity before harvest. The commercial take of yellow perch was also subject to a minimum length limit of 216 mm, intended to ensure ample sport opportunity before commercial harvest. There was no length limit on yellow perch for the recreational fishery. Besides the commercial and recreational fisheries, other extractions included a state-licensed commercial bait harvest industry that utilized public waters. Saginaw Bay was, and remains, a popular location for the bait seining industry.

Profound change came to Saginaw Bay once more in the early 2000s when alewives collapsed and disappeared from most of Lake Huron (Bence et al. 2008). Alewives used Saginaw Bay as an important spawning and nursery grounds (Fielder and Thomas 2006), and it has long been hypothesized that alewives were undermining Percid reproductive success via predation on and competition with newly hatched walleye and yellow perch fry (Fielder and Baker 2004). With release from those deleterious effects, walleye and yellow perch reproductive success surged in Saginaw Bay in 2003 and remained strong through 2010 (Fielder and Thomas 2006; Fielder et al. 2007). Subsequent numbers of harvestable (legal sized) walleyes greatly increased and fueled increases in harvest, allowing fishery managers to discontinue walleye stocking in 2006. In contrast, improved reproductive success by yellow perch has failed to increase adult abundance (Fielder and Thomas 2006).

The DNR has maintained various forms of fish harvest monitoring over the years, with fairly consistent methods since the mid-1980s. Generally, monitoring has included creel survey estimation for the recreational fishery. The first such survey was in 1983 (Ryckman 1986) but was not more consistently maintained until 1986. Monitoring in the form of direct reporting by the commercial, bait and charter boat industries also became more standardized in the mid-1980s. These data exist in a variety of databases and have been widely utilized, but access has not always been convenient, nor has there ever been a holistic examination of collective extraction from Saginaw Bay. The objective of this report is to conveniently summarize the best and most current estimates and reporting totals for the various fisheries, archiving them and avail them to researchers and managers in one location. An additional objective of this report is to relate trends in the fishery to those documented in other surveys so as to improve our understanding of the recent profound changes in the fish community. The scope of this analysis and summary is limited to Saginaw Bay (Figure 1) and portions of the Saginaw and Tittabawassee Rivers which are tributaries and can seasonally experience considerable fishing activity targeting bay fish. The reported harvest includes both the inner and outer regions of Saginaw Bay, delineated by a line between Pt. Lookout and Sand Pt. with the bay itself defined as the area from the mouth of the Saginaw River to a line between Au Sable Pt. to Port Austin.

Methods

Recreational Fishery

Creel Survey

Creel survey estimation in Saginaw Bay followed the estimation procedures described by Su and Clapp (2013). The recreational fishery in the bay was surveyed separately for the open water period (April – October) and winter (ice) fisheries (January – March) (Table 1). Surveys were normally conducted by

four clerks. Each clerk covered two areas which were subdivided into multiple sites (Table 1, Figure 1). The surveys were based on a stratified design using three-stage sampling (i.e., days, shifts and count times) within strata. Strata included site fished by month, by day-type (weekday-weekend/holiday), and by mode (method) of fishing. Catch and effort estimates are made for each stratum and then combined to give monthly and seasonal estimates.

Both weekend days and three randomly selected weekdays were sampled each week. The entire angling day from dawn to dusk was covered each month surveyed. This was accomplished by breaking each day into two 8-hour work shifts, then randomly selecting one shift to be worked. The first shift began at daylight and ended in the afternoon; the second shift began in mid-morning and ended at sunset. Monthly shift start and end times could vary due to varying length of daylight among months. The interview area was also randomly selected for each day. The clerks were instructed to interview all anglers or angling parties they encountered. An angler party was defined as one or more anglers who fished together.

The clerk interviewed each angling party or individual angler that returned to the access site during the scheduled shift. The number of interviews varied as a product of the amount of fishing effort taking place during each shift and by location. Angler party interview data were originally recorded on a Scantron® bubble form until 2003. After 2003 clerks recorded data using a portable electronic device (PDA). Interview data were reviewed throughout the field season by the Statewide Angler Survey Program staff. The software used for data entry employed range checks on various data fields for each interview record that was keyed.

Date, time, and location (site numbers where both the fishing and the interview took place) were recorded for all interviews. If a boater did not fish, that was recorded on the form as a non-fishing party and the interview was ended. If fishing did take place, anglers were queried as to their mode of fishing (i.e., boat, shore, pier, open ice, or shanty ice), where they fished, how long they fished, what species were targeted, the numbers (by species) of fish they caught and numbers kept, and the number of fishing trips they made or intended to make that day. Additional data were collected for one member of each party such as age and gender, zip code or county of residence, and the angling method used (e.g., casting, still fishing, trolling). The Statewide Angler Survey Program began tracking number of fish released by anglers in 1997. Numbers released is beyond the scope of this report and are not reported here. While hooking mortality on released fish is an additional source of mortality it was not estimated or included in this report as an additional form of extraction.

Fishing effort was determined through instantaneous counts of boats and shore anglers made from airplanes. Local flight service companies were contracted to make the aerial counts. Five flights were made each surveyed week at randomly selected starting times. All counts were recorded on count data forms by contract pilots. The proportion of boaters interviewed by creel clerks, who indicated they were not fishing, was used to adjust the aerial counts for non-fishing effort. Effort estimates were made for each site by month. Three measures of fishing effort were calculated: angler hours, angler trips and angler days. An angler trip was one completed fishing excursion. An angler day was composed of one or more fishing excursions during a 24-hour period.

Harvest estimates were made for each site by month for all fish species observed in the harvest by creel clerks. Standard mathematical formulas for creel survey (Lockwood et al. 1999; Su and Clapp 2013) were used to calculate all estimates. Uncertainty estimates for all catch and effort estimates in this report are defined as two standard errors of their mean (2 times the square root of the variance divided by the sample size for an estimate).

Harvest and effort estimates can be used to generate harvest rates. The rates presented in this report were generated over all the angling effort that occurred in the bay or port. Often anglers will target a specific

species and their targeted harvest rate is usually greater (sometimes substantially greater) than those reported here (based on total effort). An angler's target species was part of the creel survey interview, and targeted harvest rates can be generated from the statewide creel database, but are not included here. However, trends in proportions of parties targeting yellow perch and walleye are reported.

Creel clerks also collect biological data from harvested walleye and yellow perch encountered during on-site interviews. Biological data collected included total length and weight. Dorsal fin spines or rays were also collected for age determination since about 2009 and scales before then. Spines became the preferred structure because they provide the best combination of ease of collection in the field and accuracy and precision of age estimates (Clark et al. 2004). Monthly target sample sizes for age analysis were based on a minimum number needed to provide a reasonable representation of the age structure of the harvest each month, balanced with the logistical feasibility of the creel clerk to collect biological data samples without negatively impacting angler interview numbers. All samples were sectioned using a table-mounted Dremel® rotary cutting tool. Sections approximately 0.5 mm thick are cut as close to the proximal end of the spine or ray as possible. Sections were examined at 40x-80x with transmitted light, and in more recent years were photographed with a digital camera. Each digital image was archived for multiple reads. Scales were aged (before 2009) by either by first embossing on acetate or examined directly under a glass slide on a microfiche projector.

Charter reporting

Reporting of sport harvest and fishing effort by the charter fishing industry in Michigan is required under Public Act 451 (Part 445) of 1994. The law stipulates that charter operators keep an up-to-date daily log of their fishing activity onboard their vessel at all times. Charter operators were identified from (1) a list of operators who submitted catch reports the previous year, (2) review of DNR Law Enforcement Division's list of individuals who applied for and received a certificate of inspection for a fishing vessel, and (3) review of the list of individuals who applied for and received a Sport Trolling License.

Monthly charter fishing activity was reported using the Michigan Charter Boat Daily Catch Report form (MDNR form PR8206), since 1990. Minor revisions have been made to the form over the years. Online charter reporting became available for use in 2008; it was an option for charter operators to use, but was not mandatory. Both methods of reporting required the following information: a DNR assigned reporting identification number for each boat, lake fished, date fished, port of origin, 10'x10' coordinate grid where a majority of the fishing occurred on that excursion, hours fished (dock to dock), total number of anglers (resident + non-resident anglers), harvest (by number) of major species, target fish species or fish group, number of sea lamprey seen attached to Chinook salmon or lake trout, and space for comments and observations. For those chartering in the Tittabawassee or Saginaw Rivers, river fished was used in lieu of lake fished, and grid fished was omitted.

Charter operators were required by law to submit the compiled monthly report to the DNR by the tenth of each month following the month of fishing. The majority of charter businesses operated during late spring through early fall. DNR personnel organized and reviewed forms as they were received. Incomplete forms were returned to the charter operator for completion. If a report was not received for a given month, it was assumed an operator was delinquent, because one cannot distinguish those operators who did not fish from those who failed to submit a report. For months June through November, the agency issued postcard notices to charter operators who did not file a catch report from the previous month. Late in the year, those operators who did not file reports for one or more months during the period April through October were sent a final request to submit their reports. Further nonreporting after that contact was taken to mean no fishing activity occurred for that operator.

The monthly charter data were entered into a database and summarized annually to describe port-specific and bay-wide trends in fishing effort (angler hours, angler trips, and charter excursions), harvest, and harvest rates of major sport fish. The data tables in this report (1990-2010) include total harvest per species and total fishing effort (regardless of species targeted during the excursion). Charter based harvest was included in the creel survey estimation prior to 1990.

Commercial Reporting

The state-licensed commercial fishing industry was required to report their catch every month on either a paper form created and provided by the DNR or through a secure state-run online reporting system. These monthly reports were due for every license regardless of whether any fishing or harvest occurred and any license holder failing to report was subject to prosecution. The reports include descriptions of species caught by weight and by fishing location (grid), as well as the types of gear used and a description of the amount of fishing effort employed with that gear. Commercial gear was not standardized across the industry and effort was not typically expressed in individual lifts. Consequently commercial summaries in this report are primarily limited to yield and not summarized as any basis of effort. Many of the reports also provided a description of the price the fisher received per pound for the species sold. Biological data on the lake whitefish commercial harvest is periodically obtained from some operations to facilitate stock assessment needs for Lake Huron but are not summarized here. No biological data is collected from other species commercially harvested.

Bait Harvest Reporting

Persons harvesting bait for commercial purposes in Michigan were required to be licensed by the DNR. Terms of the licensing also required the annual reporting of total take in volume by species or approximate taxonomic groups that reflect commercial use. The bait harvest industry primarily targets three species of fish for harvest from the wild; emerald shiners (known in the industry as "blues"), spottail shiners (known as "grays"), and suckers (typically juvenile white suckers), as well as various other minnow species. Reporting was done by county and water body. Although reporting has been a standing requirement, compliance was largely voluntary as enforcement is difficult. Enforcement instead has focused on the requirements prohibiting the harvest, transport and sale of juvenile game species (sometimes collected as by-catch) and exotic species such as round goby and others. It is estimated that prior to 2007, reporting compliance was poor in most years. Since then, renewed efforts at communication have resulted in greater compliance. For this reason, bait harvest is summarized only for the years 2008 – 2010 but should give the reader a sense for the magnitude and diversity of bait fishes being taken from Saginaw Bay by this industry. Almost all commercial bait harvest was by beach seine.

Results

Recreational Fishery

Since 1986, 16 species have been the primary focus of recreational harvest (Table 2, Appendices 2-25). Other species are harvested as well but were generally a minor component of the fishery at any one time. Walleye and yellow perch were by far the most harvested species in all years, reflecting their abundance and recreational popularity. There were some cold water species reported as part of the Saginaw Bay fishery including Chinook salmon, lake trout, coho salmon and brown trout. However, harvest of most coldwater species are from the outer-most ports (Tawas and Port Austin, Appendices 2-25). They are uncommon in the harvest from the inner-bay ports. Brown trout have been stocked periodically at Tawas

Bay as part of a put-grow-take fishery. Most of the brown trout harvested from Saginaw Bay are believed to stem from those plants.

Walleye harvest has increased since 2005 (Table 2, Figure 2) and is attributed to food web changes in Lake Huron that favor walleye reproductive success. During the same time period, yellow perch recreational harvest has declined to its lowest levels (Table 2; Figure 2). The decline of yellow perch harvest is particularly evident in outer bay ports like Tawas (Appendices 2-25). The harvest of some species may not reflect the magnitude of their fisheries due to the practice of catch-and-release by the anglers pursuing them. This practice is particularly prevalent for smallmouth and largemouth bass anglers.

Angler effort peaked in 1987 at 2,867,994 hours and has declined since then, reaching a low of less than 1,000,000 hours in 2006 (Figure 3). This is in spite of the increase in availability of walleye. Saginaw Bay constitutes a substantial proportion of Lake Huron's (Michigan waters) annual recreational fishing effort and has accounted for the majority of effort since 2003 (Figure 4). Anglers reported targeting yellow perch more often than walleye until 2002 when walleye became the most targeted species (Figure 5). Between 1997 and 2010, anglers residing out of state averaged just 0.7% of all anglers by number with little trend over time.

The mean age of walleyes in the recreational fishery (Table 3, Appendix 26) reflected the maturing of the population and steady (but low) recruitment until a sudden increase in reproductive success resulted in substantial recruitment to the fishery in 2006, at which time the mean age dropped dramatically. Mean age of yellow perch in the recreational fishery was stable until a decrease was observed in 1997. The decline of mean age after 1997 may have reflected a depletion of older year classes stemming from a decline in recruitment that began after the colonization of zebra mussels in the early 1990s (Fielder and Thomas 2006). The decline may also have been a result of the fisheries switching to less desirable younger fish after the depletion of older, larger yellow perch (Table 3).

Although the charter fishery is considered to be part of the overall recreational fishery, and is included in Table 2, it is addressed here as well since charter anglers differ from non-charter anglers in motivation, fishing practices, and success rates. Charter fishery trends largely mirror those of the non-charter recreational fishery (Table 4) but charter harvest rates are often considerably higher. The scope of the charter fishery is more focused than the rest of the recreational fishery, reporting just seven principle species (Table 4, Appendix 27). The charter fishery operates out of many of the same ports as the larger recreational fishery but is most prevalent at Port Austin, Au Gres, Pinconning, Tawas, and Bay City (Figure 1).

Commercial Fishery

Total yield by the inner bay commercial fishery has declined steadily since 1986 from about 1,953,000 kg to about 522,000 kg by 2010 (Table 5). This decline is primarily attributed to declines in commercial participation and changes in market demand. Since 1986 the number of licenses issued for inner Saginaw Bay has gradually decreased from 27 to 20 and of those currently issued in 2010, only 9 reported harvest. During the last 25 years, the number of licenses have consolidated into fewer owners as individuals accumulated multiple licenses. Today the 20 licenses issued annually are held by only 16 individual fishing operations. In addition to the decreasing participation trends there has also been a shift in the gear fished by those licenses. In the 1980s all gear types licensed were fished (trap nets, fyke/hoop nets, gillnets, seine nets, and set hook lines). However, starting in the early 1990s (due to declines in market demand for wild-caught channel catfish and common carp) fishing by gillnet, seine, and set hook line was almost completely abandoned. While that gear still remains listed on the 20 licenses issued, in the last 10

years nearly all harvest in inner Saginaw Bay was reportedly taken by some type of impoundment gear (trap or fyke/hoop nets).

The yield of yellow perch, the principle target of the inner bay commercial fishery, has steadily declined in recent years (Figure 6) mirroring the recreational harvest trend (Figure 2). By contrast, the commercial yield in outer Saginaw Bay has increased dramatically since 2002 after a change in ownership of one license (Table 6). The outer bay fishery, principally a lake whitefish fishery, has averaged a yield in excess of 400,000 kg since 2006 (Figure 7). The gear employed in the outer bay fishery has been mainly large mesh trap nets with very little variation through time. Commercial yield for the outer bay averaged 70% of Saginaw Bay's total lake whitefish yield between 2003 and 2010.

Bait Harvest

Of the targeted bait species, emerald shiners are the most harvested in Saginaw Bay (Table 7). Total harvest was as great as 60,627 liters for all species combined. Saginaw Bay has ranged from a low of about 6% to as much as 58% of the statewide yield of commercially harvested bait. Operations reporting harvest from the waters of Saginaw Bay ranged from a low of four in 2009 to a high of 11 in 2010. Commercial bait harvest was reported in each month of the year for 2008 – 2010 but November bait harvest was the largest ranging from 39% of the yearly total in 2008 to 61% of the yearly total in 2010.

Discussion

Saginaw Bay is an enormous source of fish biomass to a variety of industries and recreational pursuits in the State of Michigan. Applying assumptions of average weights for commercial fish and typical numbers of bait fish per volume, and summing all reports and estimates, it is estimated that as many as 22 million fish were taken on average from the bay each year for the period of 2008 – 2010. While the majority of these fish were bait fish, it never the less illustrates the enormous productivity of this water body and the human demand placed on it.

The recreational fishery of the bay may well be the most obvious feature of the collective extraction. While a fairly diverse fishery composed of 16 species in most years, two percids (yellow perch and walleyes) have made up 95% of total harvest (numerically) since 2000. Many of the other species are incidentally caught while targeting walleye and yellow perch or are small niche fisheries such as smallmouth bass or brown trout. The creel survey time series began early enough to capture the initial rise of walleye fishing after its emergence from collapse in the mid Twentieth Century. That initial rise is attributed to improvements in water quality and fingerling stocking efforts by the DNR (Fielder 2002; Fielder and Baker 2004). The majority of the walleye year classes from that time until 2003 were dominated by hatchery fish (Fielder 2002). The second major development in the recreational fishery was the pronounced increase in the harvest of walleye beginning in 2006 (Table 2, Figure 2). This increase in abundance is a result of a surge in walleye reproductive success that stems from profound food web changes that began in Lake Huron in 2003 (Bence et al. 2008, Riley et al. 2008). Specifically, the disappearance of alewives from much of Lake Huron and Saginaw Bay allowed for the improvement in walleye reproduction (Fielder et al. 2007). Alewives were known as a formidable predator and competitor on newly hatched percid fry. Walleye have benefited in other parts of Lake Huron as well (Fielder et al. 2008; Fielder et al. 2010) but nowhere as much as Saginaw Bay.

The food web change and decline of alewives had dire consequences for the popular Chinook salmon recreational fishery in Lake Huron, as that species is largely an obligate pelagic predator (Bence et al. 2008). While a minor component of the Saginaw Bay recreational fishery, the Chinook salmon decline can be seen beginning in 2005 (Table 2). In spite of the great improvement in walleye fishing, recreational effort has continued to decline in the bay (Table 2, Figure 3). Effort declined more steeply in

the rest of Lake Huron than in Saginaw Bay, however, as evidenced by the increasing proportion and importance of fishing effort in Saginaw Bay (Figure 4). Recreational fishing effort is affected by a variety of factors including socioeconomic aspects. One local feature, however, may be the availability of yellow perch. Yellow perch were the single most sought-after species in the recreational fishery until 2002 when walleye surpassed them. Yellow perch have been declining in abundance due to a series of weak year classes in the 1990s and early 2000s coincident with invasion and colonization by dreissenid mussels (Fielder et al. 2000; Fielder and Thomas 2006). Like walleyes, yellow perch reproduction benefited from the decline of alewives beginning in 2003, but enhanced production of young-of-year perch has failed to translate into strong year classes due to very high first-year mortality (Fielder and Thomas 2006; in press). Abundance of adult yellow perch has been declining steadily since the early 1990s in Saginaw Bay and that trend is reflected in the harvest and yield of both the recreational (Figure 2) and commercial (Figure 6) fisheries. Other forces possibly affecting declining trends in recreational fishing effort may include increasing fuel prices, the economic recession of the 2000s, and a broader general trend away from fishing and outdoor recreation by the public.

The winter ice fisheries are an important component of the annual recreational fishery in Saginaw Bay in some years. Ice fishing effort is highly variable because its magnitude is dependent on the period and spatial extent of ice cover and overall weather conditions. Yellow perch harvest totals for the year can be greatly affected by the ice fishery, for example in 2002 the ice season accounted for 58% of the total annual perch harvest. Some species are primarily harvested during the winter ice fishery, such as bluegill (98% of the annual harvest) in 2000. In most years, the months of November – December are the lowest periods of recreational fishing effort, and hence they are usually not surveyed by the DNR creel survey program.

Notably absent from these fishery statistics are certain species that historically were some of the most substantial components of the fishery. Cisco yield in the commercial fishery from 1903 to 1955 averaged 1,176,936 kg/yr (Baldwin and Saalfeld 1962). Cisco today constitutes a potential commercial and recreational species in Lake Huron. More significant, perhaps, is the ecological loss this missing species represents in terms of the role it played as a forage fish in Saginaw Bay as well as the rest of Lake Huron. Lake sturgeon have also been a feature of the historic Saginaw Bay fishery with yields as great as 25,000 kg (Baldwin and Saalfeld 1962). Lake sturgeon are a State-of-Michigan-listed threatened species and are largely closed to harvest statewide. This is another historic element of Michigan's fishery heritage that is missing from the modern day fishery.

Estimation and monitoring issues

Uncertainty about the magnitude of the non-charter recreational fishery exist because these metrics are estimated as opposed to full reporting by other segments of the fisheries. Expression of confidence intervals as a result of standard error values offer measures of variability about the estimates but other forms of bias can exist as well. Its notable that the design of the creel survey used in Saginaw Bay probably under estimates night time fishing. No counts or interviews of night time fishing occurs although early morning interview shifts may capture some night anglers returning from their trips. Night fishing can be significant for some species like walleye. This bias in the creel survey design would serve to under estimate effort and harvest of fish. Another bias is that that there was no means to reduce effort estimates by charter boats fishing. Aerial counts of boats would count charter boats along with all others. Interview questions help eliminate nonfishing boating traffic from estimates of effort but no similar reduction was made for charter boats (which report their harvest directly outside the creel survey). This bias would serve to overestimate harvest and effort although at any one time, its improbable that charter vessel traffic was great enough to bias the estimates to any substantial degree.

Uncertainty was not limited to creel estimates in the recreational fishery. Direct reports are also subject to misreporting or failure to report. Varying degrees of effort were made to ensure reporting compliance with the greatest effort perhaps made for the charter boat program and likely the least effort for the bait harvest reporting. The wide span of values in Table 7 for 2008 – 2010 suggest that bait harvest reporting may still not be assured or accurate. In spite of the inherent biases of the creel survey program and potential for misreporting or failure to report in the other fisheries, the system in place constitutes a valuable source of information for managers and serves as a gauge for management efforts and facilitates research such as stock assessment.

Commercial management is made more difficult by the difficulty of fully assessing effort. For example it is difficult to derive a meaningful catch-per-unit-of-effort in the commercial fishery in Saginaw Bay as fishers were not required to report catch by net lift or duration of soak time between lifts during the reporting period. Recent administrative licensing changes now mandate the reporting of lifts (number and timing) beginning in 2012. Number of commercial fishing licenses reporting no harvest, however, serves as an indicator of participation for this fishery.

Economics of the Saginaw Bay fisheries

The charter boat fishery is a relatively minor subcomponent of the larger recreational fishery in Saginaw Bay, but remains an important service for many anglers who may otherwise not be able to participate. The charter or guided element of this fishery is yet another economic component and is estimated to have increased in economic activity to $500,000 in 2009, a more than $350,000 increase over the years 1990-2002 (O'Keefe and Miller 2011). The United States Department of Interior (2006) estimates that in 2006, Great Lakes anglers spent in general an average of $50.93 per trip for Great Lakes recreational fishing in Michigan. Applying this value, Saginaw Bay recreational fishing generated an average of more than $33 million in economic activity each year between 2008 and 2010.

In inner Saginaw Bay, commercial participation has declined greatly to the point where less than half the licenses reported harvest in 2010 (Table 5). The motivation or demographics of commercial fishers in inner Saginaw Bay are not well understood, but it is generally believed that participation is being driven by two factors; the availability of marketable fish and the age of the commercial license holder. Yellow perch have been the primary focus of much of the inner bay fishery and participation has declined in concert with yellow perch declines. Consumption advisories and contaminant concerns have probably driven a decline in market for the sale of carp and channel catfish. As license holders have aged, declining participation may reflect retirement or pursuit of other forms of income. Commercial fishing licenses in Michigan are deemed private property and can be sold or essentially inherited. It is possible that younger generations in commercial fishing families are choosing other careers or forms of business.

Participation rates in the commercial fishery of outer Saginaw Bay have remained stable. Catch (probably driven by individual fishing effort or intensity) by one license has risen sharply leading to an increase in lake whitefish yield since 2003 (Figure 7). The two outer bay licenses target lake whitefish exclusively. The commercial fisheries of Saginaw Bay are regulated by minimum length limits for yellow perch (216 mm) and for lake whitefish (483 mm in the outer bay, 432 mm in the inner bay). Quota management of commercial take is employed by the DNR on some fishers in the Great Lakes, but there are no quota limitations on any fishers in Saginaw Bay. Market prices for fish in the round (whole fish uncut) fluctuate but lake whitefish has ranged between $0.99 and $2.67/kg (in the round) in recent years (Daniels 2003; Michigan DNR unpublished data). In 2010, lake whitefish commanded $2.67/kg in the round and yellow perch $5.09/kg (Michigan DNR unpublished data). Based on these values, between 2003 and 2010 the dock-side value (in the round) of the Saginaw Bay lake whitefish fishery averaged $1,399,997 and yellow perch $174,925 annually. The yellow perch yield probably peaked in 1995 at an estimated value of $615,193.

The commercial fishery in Saginaw Bay was required to release unpermitted by-catch species. The commercial by-kill of walleye and lake trout are two additional forms of commercial extraction that are not readily obvious. Mortality of by-catch (by-kill) was the subject of a 2010 study by Michigan State University (MacMillan and Roth 2012). That study estimated that 51,190 walleyes were incidentally caught between May and August (almost entirely in the inner bay fishery) and of those 42% or 21,500 were morbid. Expressing that rate across the entire year's commercial effort, walleye by-kill may have been as great as 101,872 fish annually. Similarly, by-kill of lake trout was estimated to be 2,980 from May – August, 2010 (almost entirely in the outer bay fishery). Values are not presently available for years outside 2010. While walleye abundance was greater in recent years than in the past, commercial effort was also much greater in the past for inner Saginaw Bay (Table 5). Thus, commercial by-catch issues may have been significant during this entire reporting period.

MacMillan and Roth's (2012) estimate of 21,500 morbid walleye for the May – August period and the extrapolated value of 101,872 for the entire year represents 12% and 56% of the recreational harvest of walleye that same year (2010). It's unclear how significant this form of extraction is to the overall sustainability of the walleye population but clearly is not a negligible value. Applying a commercial dock-side value to these numbers of walleyes of $4.03/kg (DNR unpublished data) and an assumed mean weight of 1 kg/fish, the lost (whole fish) value may be as much as $86,922 to more than $395,000. The value these fish may have represented to the recreational fishery is more difficult to evaluate. By applying an assumed exploitation rate of 25% and a mean harvest of 0.31 walleye per trip in 2010 (Table 2) and at $50.93 of economic activity per recreational fishing trip (US Department of Interior 2006), the recreational dollar equivalent lost would range from $84,845 to $402,096 in lost economic activity. These values rival or greatly exceed the dock-side value of the yellow perch inner bay commercial fishery that is the primary target of most of the netting that inflicts the walleye by-kill.

Hooking mortality might be thought of as a recreational equivalent of by-catch. Mortality of walleyes caught and released on live bait can be as great as 10% (Payer et al. 1989). The minimum length limit of walleyes (381 mm) in the recreational fishery undoubtedly mandates that some walleyes are released. Estimated catch and release of walleyes in the recreational fishery (sport and charter combined) amounted to an average of 85,774 per year between 2008 – 2010 (Michigan DNR, unpublished data). Applying the live bait mortality rate from Payer et al. (1989), as many as 8,577 walleyes may have died from hooking mortality each year for the same time period.

The economic value of the bait fish industry might be derived by applying a generic wholesale value of $6.60/liter of bait fish (Meronek et al. 1997) , assuming all bait harvested is sold. At that rate, the bait fish industry earned a minimum estimate of $4.28 million from Saginaw Bay between 2008 and 2010. There is also the nonmonetary value of this industry, as a service to the rest of the angling pubic by availing a reliable supply of live bait to facilitate angling.

The average collective economic impact of fish extraction in Saginaw Bay (based on years 2008 – 2010) was $38.9 million with the vast majority of that (92%) stemming from the recreational fishery. It is more difficult to assign a value to the place this natural resource holds in importance for the citizens of Michigan who participate in these fisheries or appreciate the cultural and heritage values of their existence.

Recommendations

1. The Saginaw Bay open-water and winter ice creel surveys should continue uninterrupted as an annual project, preserving comparability to past survey years. The importance of this work transcends this reporting as it is used in various modeling efforts and to gauge the effects of

management. Saginaw Bay now produces the majority of the recreational fishing effort in Lake Huron.

2. The by-kill of sport species in the commercial fishery needs to be better quantified. On-board monitoring should be implemented and examined to more fully assess the range of by-kill among years, across various fishing operations, and for all the months of the commercial fishing season. Management efforts should seek to minimize commercial by-kill.

3. Currently biological data are collected on a subsample of fish harvested by the recreational fishery. Similar biological sampling should occur for commercially harvested species. A bay-wide analysis of the age and size structure of the fish harvested by these fisheries should be conducted and reported out in a fashion similar to this report.

4. The Michigan DNR should institute additional follow-up efforts and enforcement of commercial and bait harvest reporting to increase compliance and ensure accuracy.

5. A more thorough analysis of the economics behind the various fisheries and sources of extractions for Saginaw Bay is in order and would help fishery managers evaluate tradeoffs and management priorities.

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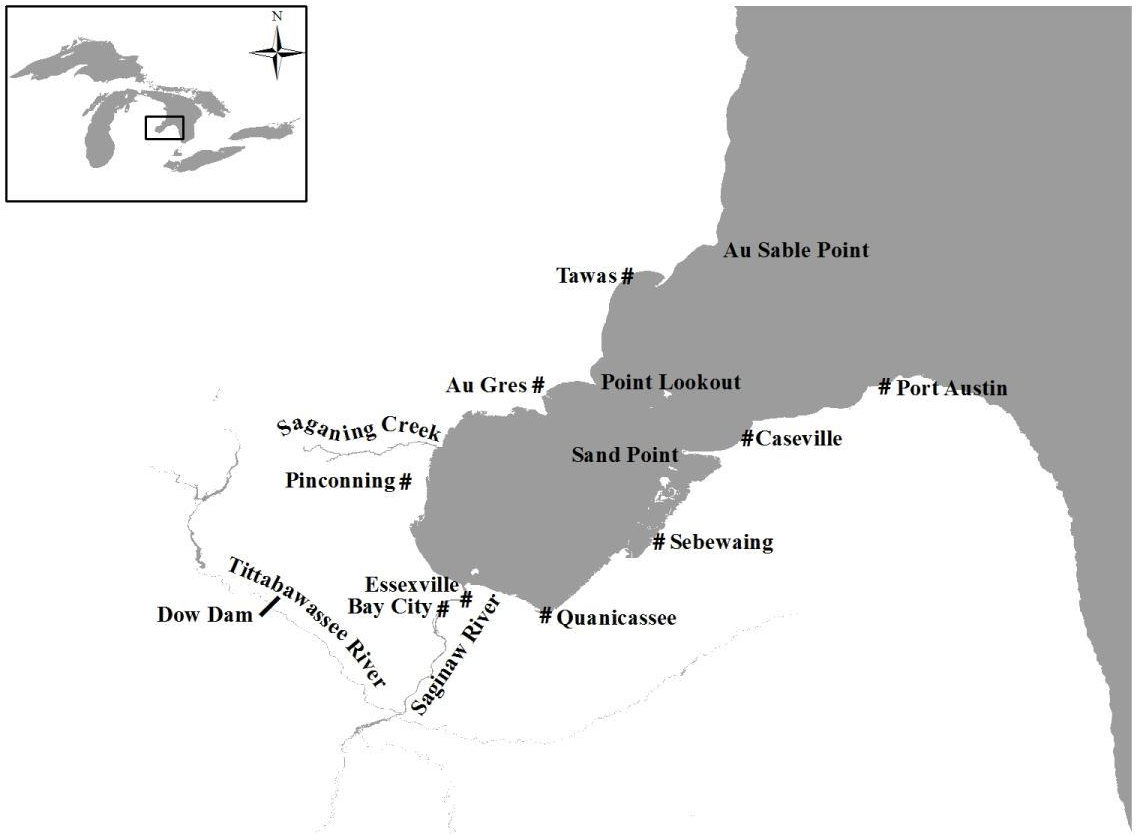

Figure 1. Saginaw Bay, Lake Huron.

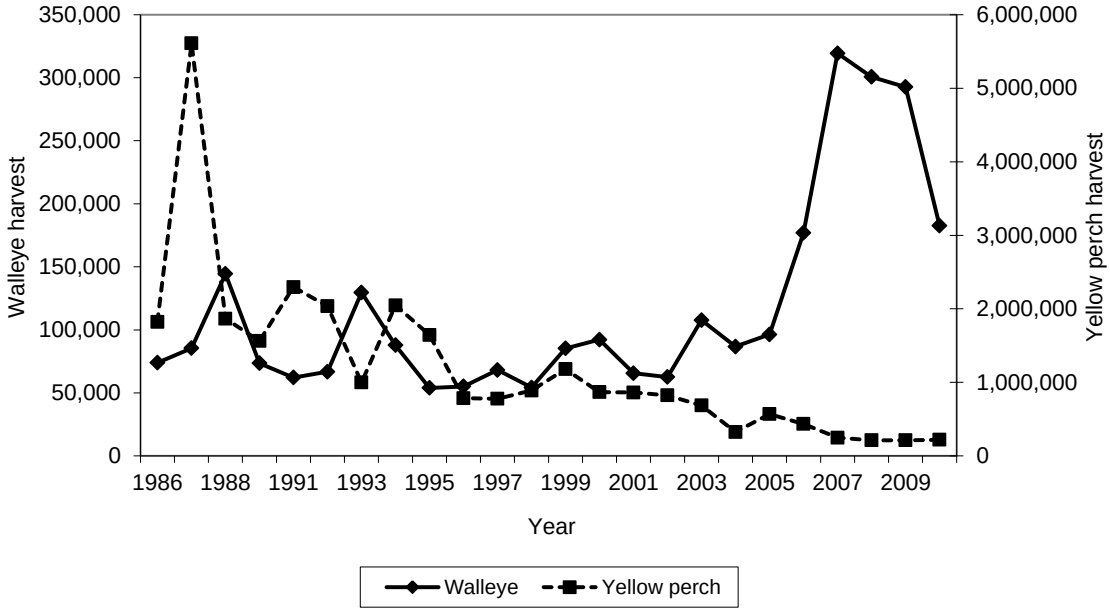

Figure 2. Numbers of walleye and yellow perch harvested by the recreational fishery in Saginaw Bay 1986 – 2010.

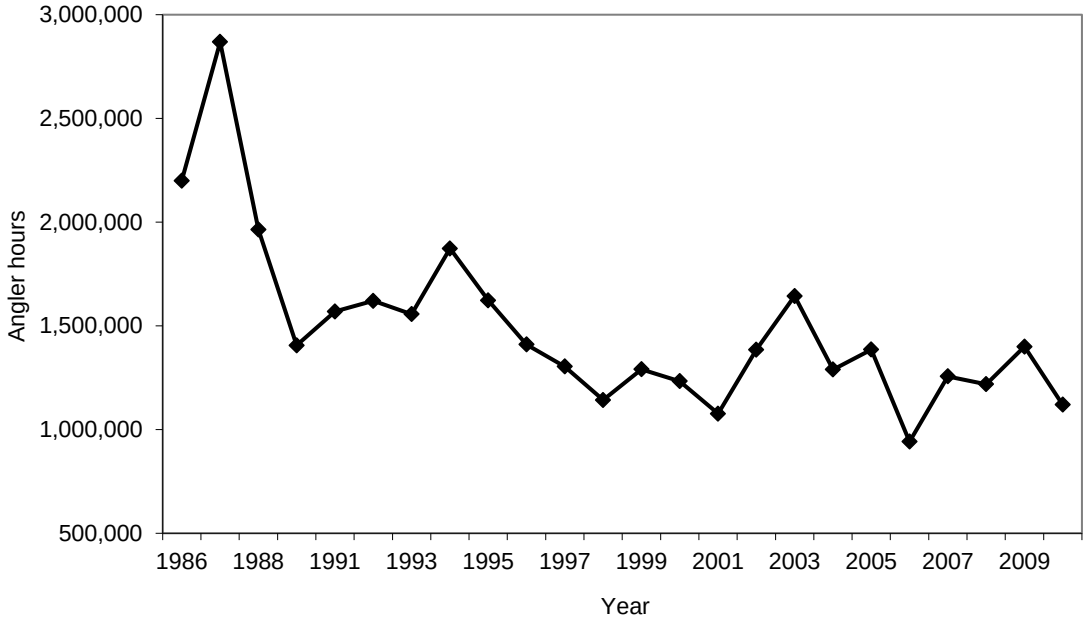

Figure 3. Estimated recreational angling effort (in total angler hours) in Saginaw Bay 1986 – 2010.

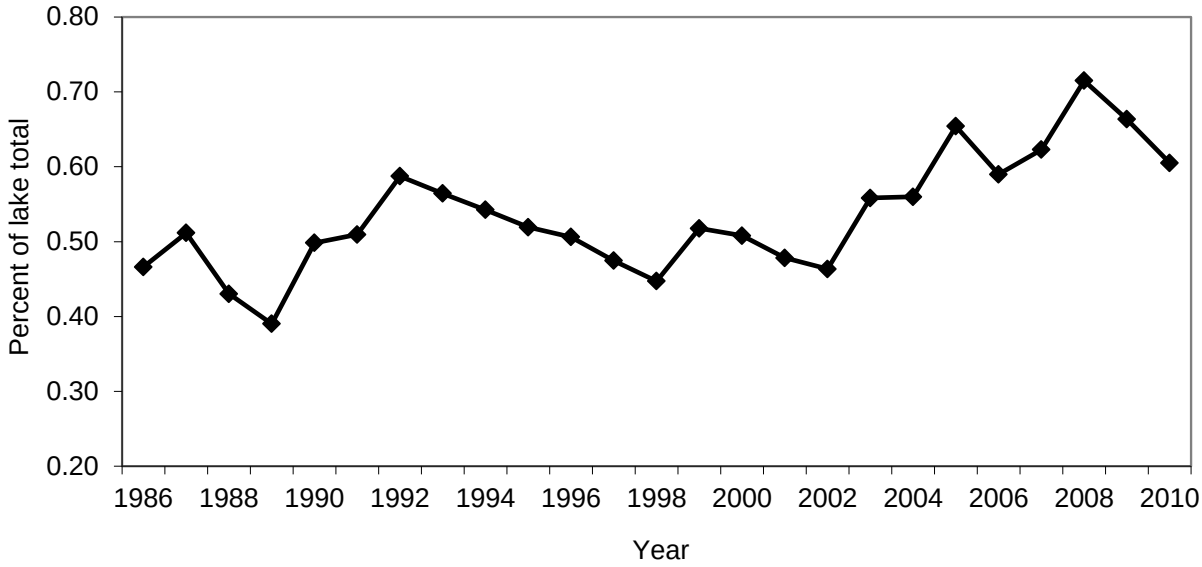

Figure 4. Saginaw Bay annual recreational fishing effort estimated as a proportion of Lake Huron's total (Michigan waters only) 1986-2010.

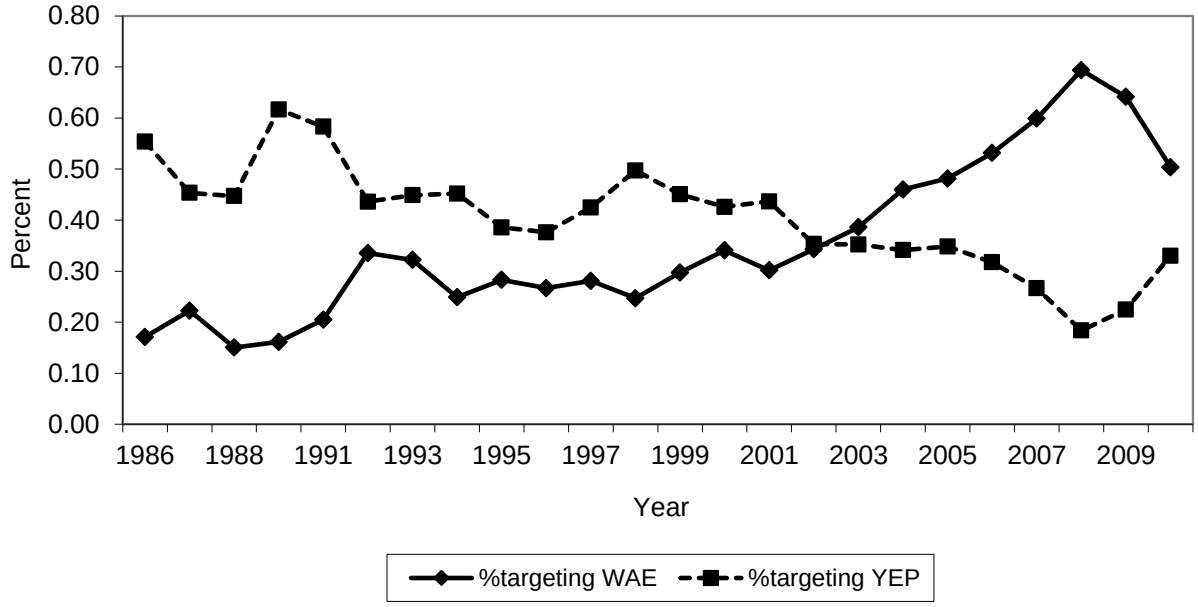

Figure 5. Percent of anglers reporting they are targeting walleye (WAE) or yellow perch (YEP) in Saginaw Bay's recreational fishery 1986 – 2010.

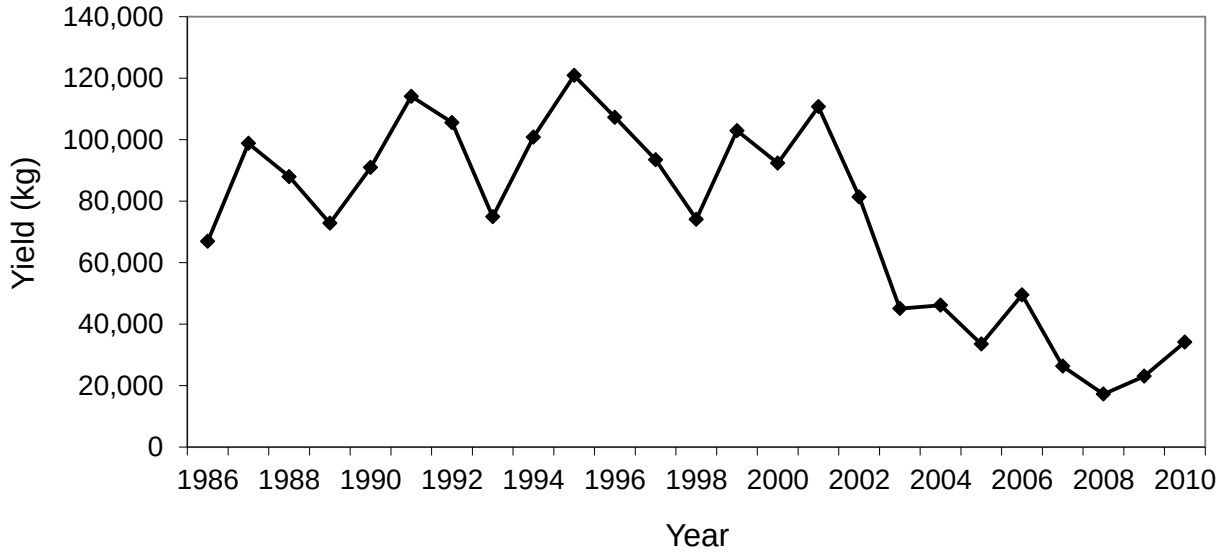

Figure 6. Yield in round (whole) kg of yellow perch from the inner Saginaw Bay commercial fishery 1986 – 2010.

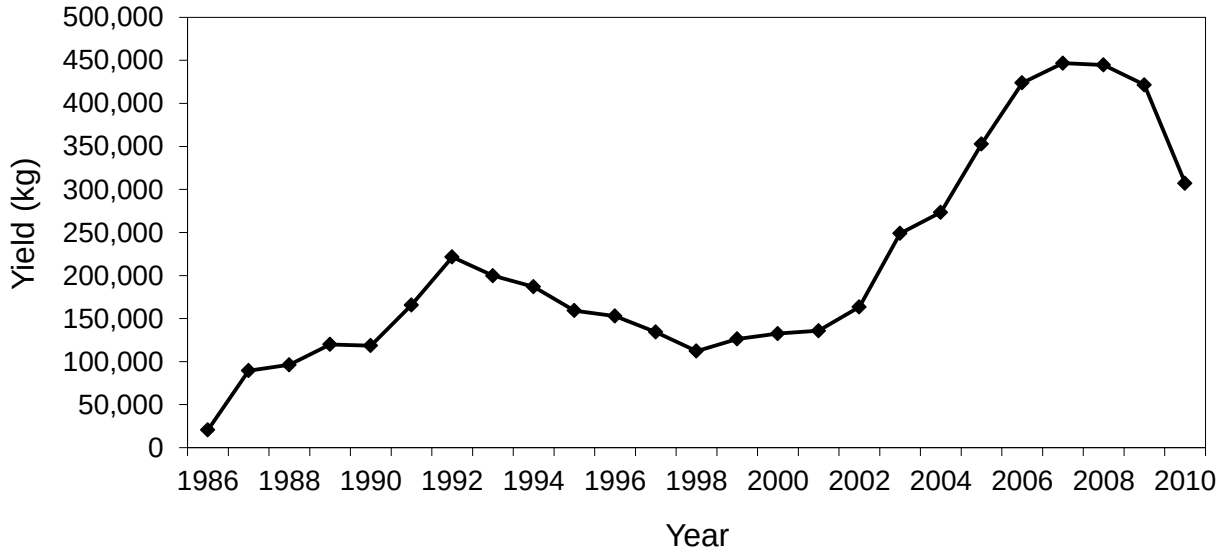

Figure 7. Yield in round (whole) kg of lake whitefish from the outer Saginaw Bay commercial fishery, 1986 – 2010.

Table 1. Locations and years of creel survey on Saginaw Bay. Open water months were April – October and winter months were January-March.

		Year																								
Open water creel survey locations																										
Survey location	Site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Port Austin	236	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tawas	250	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AuGres	255	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Saganing Creek to Sag. R.	260	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Saginaw R. to Quanicassee	356	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Quanicassee to Sebewaing	278	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sebewaing to Sand Point	288	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sand Point to Port Austin	236	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Caseville	290						X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]
Saginaw River	355	X	X	X											X	X	X	X	X							
Tittabawassee River[1]	401														X	X	X	X	X	X	X	X	X	X	X	X
Winter creel survey																										
Port Austin	236		X	X			X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Saginaw R. to Quanicassee	356		X	X			X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Tawas	250		X	X			X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Au Gres	255		X	X	X		X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Saganing Creek to Sag. R.	260		X	X	X		X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Quanicassee to Sebewaing	278		X	X			X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Sebewaing to Sand Point	288		X	X	X		X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Caseville[3]	290						X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Saginaw River	355			X											X	X	X	X	X	X	X	X	X	X	X	X
Tittabawasee River	401														X	X	X	X	X	X	X	X	X	X	X	X

[1]March, April and May

[2]Added in 2004, but was included with site 236 from 1990 - 2003.

Table 2. Estimated harvest, and effort (angler hours, trips and days) for Saginaw Bay (all sites) - by all modes (including Charter) of sport fishing, 1986-2010. Two standard errors of the mean in parentheses.

	Year											
Species	1986	1987	1988	1989	1991	1992	1993	1994	1995	1996	1997	1998
Brown trout	7,490	1,920	888	288	242	420	725	3,058	4,396	5,678	1,567	1,169
	(5,206)	(854)	(664)	(292)	(245)	(216)	(472)	(NAN)	(1,354)	(1,573)	(1,839)	(432)
Channel catfish	77,957	38,371	48,327	23,354	28,366	20,707	56,824	17,529	12,932	10,552	0	0
	(24,513)	(11,035)	(51,733)	(11,284)	(11,415)	(5,760)	(17,607)	(NAN)	(4,262)	(3,769)	(0)	(0)
Chinook salmon	10,798	11,543	11,211	4,422	2,158	3,625	3,438	2,186	4,515	5,659	14,320	9,274
	(4,352)	(2,405)	(3,065)	(1,491)	(856)	(1,294)	(1,083)	(NAN)	(1,606)	(1,501)	(10,528)	(2,005)
Coho salmon	1,737	375	425	268	143	137	108	35	46	46	49	247
	(1,523)	(227)	(244)	(223)	(239)	(164)	(145)	(NAN)	(71)	(68)	(203)	(296)
Freshwater drum	13,276	5,252	3,873	3,287	6,089	6,498	6,196	4,037	3,516	3,240	0	0
	(6,633)	(2,148)	(2,521)	(2,596)	(2,521)	(5,749)	(1,595)	(NAN)	(1,722)	(2,830)	(0)	(0)
Lake trout	19,590	10,517	7,205	7,484	1,914	3,298	592	2,650	4,861	3,525	9,321	11,780
	(6,270)	(2,813)	(2,264)	(3,159)	(856)	(1,935)	(519)	(NAN)	(2,442)	(1,209)	(8,496)	(5,441)
Largemouth bass	2,915	3,447	3,075	996	1,096	1,092	1,414	1,937	343	691	0	0
	(1,466)	(2,192)	(1,400)	(854)	(1,005)	(920)	(1,220)	(NAN)	(632)	(560)	(0)	(0)
Northern pike	662	4,024	1,600	312	1,709	3,697	1,964	1,280	904	895	0	0
	(497)	(1,922)	(1,446)	(244)	(1,145)	(1,373)	(1,186)	(NAN)	(418)	(532)	(0)	(0)
Other	5,487	6,332	1,100	2,399	1,722	307	1,128	4,690	2,387	32,967	0	0
	(3,311)	(9,673)	(645)	(4,542)	(3,991)	(200)	(1,227)	(NAN)	(1,852)	(23,615)	(0)	(0)
Pumpkinseed	1,237	7,186	8,625	480	1,070	1,246	309	158	0	109	0	0
	(973)	(3,789)	(8,007)	(430)	(885)	(1,180)	(294)	(NAN)	(0)	(165)	(0)	(0)
Rainbow trout	3,907	1,618	1,027	610	215	889	1,075	1,035	1,906	1,511	1,787	1,199
	(6,502)	(547)	(622)	(527)	(156)	(379)	(490)	(NAN)	(973)	(667)	(2,018)	(531)
Rock bass	1,602	1,120	776	1,313	943	1,422	1,094	649	169	327	0	0
	(758)	(664)	(569)	(2,040)	(631)	(1,288)	(820)	(NAN)	(262)	(373)	(0)	(0)
Smallmouth bass	1,054	148	1,199	535	2,269	2,274	1,443	1,937	1,648	1,616	647	254
	(841)	(115)	(1,277)	(497)	(1,772)	(3,394)	(1,030)	(NAN)	(1,050)	(1,102)	(2,284)	(201)
Walleye	73,911	85,517	144,376	73,543	62,163	66,783	138,732	87,774	51,861	49,878	68,119	64,414
	(29,378)	(12,923)	(31,113)	(15,783)	(10,877)	(8,785)	(18,786)	(NAN)	(9,352)	(9,044)	(29,683)	(8,289)
White bass	59,827	34,211	17,644	4,891	5,535	5,702	6,219	2,454	1,719	875	0	0
	(23,386)	(11,188)	(10,560)	(4,299)	(4,332)	(3,986)	(2,207)	(NAN)	(1,741)	(772)	(0)	(0)
White perch	113	1,647	994	3,391	3,653	2,032	2,187	2,031	1,022	2,120	0	0
	(132)	(1,522)	(1,515)	(2,712)	(2,205)	(1,075)	(3,429)	(NAN)	(948)	(3,172)	(0)	(0)
Yellow perch	1,820,290	5,610,835	1,866,128	1,562,774	2,296,137	2,035,408	1,046,567	2,047,247	1,600,528	778,320	669,910	889,332
	(290,945)	(555,066)	(274,885)	(207,173)	(309,889)	(207,099)	(114,626)	(NAN)	(222,868)	(129,623)	(239,839)	(108,782)
Angler hours	2,198,962	2,867,994	1,963,997	1,405,225	1,568,887	1,620,098	1,643,545	1,872,628	1,531,201	1,407,729	1,258,308	1,208,703
	(175,236)	(140,421)	(169,626)	(105,736)	(119,068)	(105,335)	(117,836)	(NAN)	(106,059)	(107,604)	(92,896)	(76,286)
Angler trips	714,133	1,475,665	738,583	545,780	600,068	686,275	662,712	436,401	709,316	548,314	328,715	442,470
	(34,783)	(38,454)	(39,417)	(22,667)	(26,483)	(24,345)	(25,198)	(NAN)	(22,603)	(23,027)	(19,654)	(18,157)
Angler days	689,762	1,449,087	706,433	536,308	589,430	674,603	636,619	375,420	694,523	532,565	309,821	434,411
	(33,271)	(36,156)	(37,081)	(21,827)	(25,864)	(22,939)	(23,243)	(NAN)	(20,160)	(21,060)	(17,961)	(16,317)

Table 2 continued.

	Year											
Species	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Brown trout	850	1,830	989	3,755	4,008	1,732	1,111	189	60	77	69	33
	(350)	(699)	(514)	(1,151)	(943)	(660)	(409)	(144)	(74)	(79)	(52)	(27)
Channel catfish	5,475	6,274	7,628	16,090	14,966	23,970	19,856	11,068	10,052	6,825	14,837	5,064
	(1,800)	(2,342)	(2,096)	(5,688)	(5,308)	(8,283)	(13,276)	(4,872)	(5,291)	(3,316)	(7,205)	(2,018)
Chinook salmon	8,495	6,667	5,540	23,013	16,319	4,650	670	513	231	89	46	26
	(2,213)	(1,960)	(1,383)	(4,113)	(3,363)	(1,239)	(266)	(397)	(157)	(68)	(47)	(21)
Coho salmon	114	131	37	1,259	161	263	46	0	364	408	88	80
	(83)	(83)	(42)	(718)	(132)	(308)	(52)	(0)	(446)	(429)	(118)	(36)
Freshwater drum	3,087	3,343	2,944	2,072	2,640	372	858	656	664	1,087	1,168	615
	(1,841)	(1,551)	(1,063)	(984)	(1,019)	(278)	(741)	(571)	(414)	(437)	(624)	(416)
Lake trout	9,138	6,134	5,140	6,453	10,525	17,888	7,261	2,031	2,880	1,101	1,586	1,608
	(3,057)	(2,055)	(1,945)	(1,908)	(2,612)	(5,298)	(2,575)	(860)	(2,245)	(401)	(581)	(71)
Largemouth bass	1,733	191	288	345	851	284	212	120	117	340	301	12
	(1,172)	(162)	(267)	(349)	(897)	(271)	(270)	(149)	(167)	(284)	(374)	(24)
Northern pike	1,498	5,787	3,255	1,720	1,963	1,454	822	995	1,202	1,004	3,244	604
	(453)	(644)	(1,057)	(528)	(732)	(485)	(294)	(403)	(605)	(584)	(2,772)	(312)
Other	1,990	384	870	3,433	969	105	163	48	156	271	370	7,184
	(1,448)	(407)	(567)	(5,545)	(1,358)	(192)	(285)	(52)	(174)	(89)	(153)	(5,447)
Pumpkinseed	518	615	112	560	1,009	260	60	75	48	32	320	3
	(384)	(620)	(132)	(1,072)	(1,478)	(372)	(71)	(72)	(48)	(53)	(499)	(6)
Rainbow trout	1,664	1,604	1,271	2,349	1,272	1,518	432	142	357	101	79	145
	(542)	(552)	(380)	(634)	(421)	(571)	(245)	(99)	(134)	(94)	(63)	(91)
Rock bass	606	750	763	415	482	285	565	833	232	663	1,090	107
	(691)	(501)	(332)	(177)	(419)	(272)	(786)	(719)	(168)	(667)	(1,261)	(111)
Smallmouth bass	433	285	159	1,469	2,570	2,088	1,169	483	563	394	713	523
	(258)	(259)	(132)	(724)	(1,591)	(1,622)	(910)	(302)	(413)	(279)	(458)	(424)
Walleye	67,213	102,011	72,290	64,479	98,203	87,276	83,441	154,524	307,619	298,286	317,050	211,206
	(11,891)	(17,439)	(9,005)	(8,617)	(13,033)	(8,758)	(9,938)	(17,656)	(32,548)	(33,542)	(35,487)	(23,793)
White bass	742	1,305	923	840	724	1,376	1,835	462	114	1,777	525	708
	(442)	(710)	(684)	(459)	(606)	(2,066)	(1,807)	(461)	(111)	(1,290)	(405)	(976)
White perch	1,355	631	623	110	495	253	284	949	2,880	214	119	162
	(1,952)	(785)	(935)	(107)	(411)	(251)	(346)	(591)	(4,345)	(190)	(195)	(151)
Yellow perch	1,213,242	880,367	868,783	838,155	655,133	322,416	527,563	445,826	242,363	218,713	195,886	243,520
	(149,415)	(108,060)	(140,239)	(94,366)	(81,069)	(51,308)	(79,187)	(63,997)	(40,902)	(34,067)	(39,245)	(37,679)
Angler hours	1,249,898	1,271,804	1,078,838	1,389,255	1,580,407	1,261,762	1,376,090	895,975	1,269,990	1,179,499	1,410,393	1,259,048
	(96,344)	(100,481)	(65,084)	(81,781)	(91,321)	(72,197)	(87,367)	(62,154)	(84,009)	(89,148)	(130,840)	(92,118)
Angler trips	438,554	487,082	400,279	587,226	723,141	552,515	783,023	392,640	515,506	567,325	741,524	686,332
	(18,686)	(21,994)	(14,836)	(18,431)	(20,610)	(17,386)	(19,898)	(13,893)	(17,190)	(18,155)	(26,173)	(19,278)
Angler days	430,270	476,685	390,880	572,892	711,477	544,489	776,203	388,894	510,718	564,211	737,995	684,560
	(17,581)	(21,360)	(13,761)	(17,181)	(19,327)	(16,127)	(18,244)	(13,483)	(16,274)	(16,519)	(24,421)	(19,027)

Table 3. Summary of biological data collected from Saginaw Bay during the winter and open-water sport fishery for the years 1986-2010. N = sample size.

Species	Year	N	Mean age	Mean total length (mm)	Mean weight (kg)
Walleye	1986	49	4.1	515	1.43
	1987	563	3.3	474	1.14
	1988	396	4.2	487	1.17
	1989	59	3.9	534	1.66
	1990	*No*	*survey*	*was*	*performed*
	1991	491	4.6	516	1.52
	1992	224	5.2	554	1.83
	1993	631	5.6	552	1.74
	1994	499	5.8	552	1.83
	1995	425	6.5	570	1.96
	1996	401	6.6	561	1.87
	1997	326	6.4	564	1.84
	1998	437	5.9	546	1.61
	1999	306	5.8	548	1.61
	2000	397	5.2	525	1.48
	2001	491	5.5	537	1.67
	2002	375	5.5	546	1.65
	2003	449	5.3	539	1.59
	2004	360	4.9	522	1.39
	2005	372	7.1	540	1.48
	2006	373	4.0	473	1.04
	2007	342	4.2	466	0.96
	2008	585	4.4	472	1.01
	2009	675	4.9	482	1.05
	2010	273	5.0	469	0.98
Yellow perch	1986	455	3.9	202	0.12
	1987	1628	4.2	196	0.13
	1988	1286	4.8	197	0.12
	1989	1238	4.1	187	0.08
	1990	*No*	*survey*	*was*	*performed*
	1991	1658	4.4	198	0.26
	1992	1760	5.0	206	0.15
	1993	1451	4.4	200	0.13
	1994	1229	4.7	201	0.14
	1995	1372	4.8	209	0.12
	1996	1239	4.0	202	0.10
	1997	878	2.8	198	0.10
	1998	883	3.2	201	0.109
	1999	1173	2.6	198	0.17
	2000	1403	3.8	203	0.22
	2001	1146	3.4	209	0.12
	2002	1214	3.4	215	0.13
	2003	1039	2.9	205	0.12
	2004	971	3.0	208	0.12
	2005	823	2.9	212	0.14
	2006	787	2.7	203	0.12
	2007	645	2.8	212	0.14
	2008	637	2.8	217	0.15
	2009	448	3.2	200	0.12
	2010	452	2.3	211	0.13

Table 4.—Total fishing effort (angler hours, anglers, and charter excursions) and number of fish harvested annually by charter boats fishing waters of Saginaw Bay and its tributaries (Tawas to Port Austin), 1990-2010.

Year	Angler hours	Anglers	Excursions	Coho salmon	Chinook salmon	Rainbow trout	Brown trout	Lake trout	Yellow perch	Walleye
1990	16,209	2,836	751	22	347	23	6	893	7,621	3,295
1991	17,509	2,889	768	23	242	46	15	456	4,992	3,669
1992	11,149	1,888	486	1	94	15	2	187	3,149	2,840
1993	9,242	1,614	413	9	104	30	5	178	1,455	2,471
1994	7,146	1,236	323	2	73	24	149	79	2,022	2,048
1995	11,298	2,004	398	3	254	95	147	321	1,952	1,645
1996	10,890	1,943	390	0	223	56	108	297	1,513	1,756
1997	9,220	1,583	337	2	417	80	46	249	853	1,508
1998	12,696	2,257	456	16	488	79	50	339	1,654	2,276
1999	13,311	2,328	448	16	345	71	5	367	5,582	2,162
2000	14,781	2,464	443	31	277	41	13	1,053	2,332	2,587
2001	12,478	2,105	371	5	195	51	4	833	1,766	2,190
2002	10,718	1,815	380	22	629	56	56	835	507	1,276
2003	10,923	1,847	410	17	744	39	86	944	494	1,548
2004	10,370	1,770	399	12	215	25	34	1,638	138	1,422
2005	9,048	1,595	401	7	83	20	2	2,382	73	982
2006	9,921	1,817	452	25	85	44	3	2,605	185	2,281
2007	9,726	1,770	453	8	32	14	0	1,495	44	4,260
2008	9,574	1,724	445	15	23	18	1	680	189	5,685
2009	14,007	2,495	641	1	6	24	1	925	86	7,334
2010	13,191	2,356	618	2	9	21	4	606	959	5,024

Table 5. Yield of fishes from the state-licensed Commercial fishery in inner Saginaw Bay; 1986-2010. Yield in round (whole) kg. Other species include: alewife, bowfin, bullhead spp., burbot, Chinook salmon, bloater chub, longnose gar, gizzard shad, menominee, rainbow trout, rainbow smelt (Chinook salmon, rainbow trout, and bloater chub were harvested illegally).

															Inner bay licenses	
Year	Whitefish	Yellow perch	Channel catfish	Carp	Sheepshead	Sucker spp.	Quillback	Buffalo	Crappie	Rock bass	White bass	White perch	Other	Total yield	No. issued	No. reporting no harvest
1986	168,064	66,944	586,499	850,128	37,840	126,022	55,934	323	11,038	84	19,763	314	30,195	1,953,148	27	0
1987	124,550	98,759	538,208	952,918	39,060	82,219	32,378	1,195	13,831	259	15,232	983	39,462	1,939,054	27	0
1988	140,894	87,940	507,523	666,774	22,132	128,496	30,493	1,324	10,807	1,043	6,749	2,678	28,243	1,635,096	27	0
1989	171,718	72,811	659,527	571,537	32,942	132,871	49,490	10,049	11,459	735	14,562	17,100	22,587	1,767,388	27	0
1990	202,191	90,936	725,528	479,449	47,424	137,705	48,835	47,400	5,904	1,323	31,754	43,748	35,523	1,897,720	27	1
1991	188,137	114,073	616,555	241,862	54,114	164,212	120,232	0	2,874	479	19,104	15,943	25,791	1,563,376	27	2
1992	296,026	105,554	466,458	123,605	40,141	110,620	110,023	0	3,407	60	36,322	11,291	36,882	1,340,389	27	2
1993	351,599	74,907	371,124	80,768	50,744	83,537	65,193	0	342	79	13,447	3,383	18,305	1,113,428	26	2
1994	395,008	100,806	338,754	88,645	39,803	124,027	68,273	7	176	102	4,969	4,198	47,228	1,211,996	25	3
1995	325,196	120,863	343,470	51,560	61,042	100,747	62,589	0	142	275	8,118	7,503	6,292	1,087,797	24	3
1996	405,741	107,247	317,755	77,290	42,310	55,165	50,047	0	236	574	5,759	8,296	15,343	1,085,763	24	2
1997	531,946	93,437	372,044	64,971	76,114	80,485	56,900	0	1,319	190	2,757	8,181	15,258	1,303,602	24	2
1998	498,326	74,085	241,761	45,193	46,552	46,441	79,424	0	3,482	1,626	3,264	1,453	18,167	1,059,774	24	4
1999	466,746	102,919	203,940	18,975	41,928	38,164	90,668	11	2,525	1,948	5,065	4,019	20,868	997,776	24	8
2000	337,907	92,349	233,889	41,596	25,113	13,592	62,673	12	1,593	2,084	1,362	4,863	23,489	840,522	24	8
2001	209,610	110,721	296,650	54,740	34,253	18,100	74,256	0	1,483	2,402	975	6,224	4,153	813,567	24	6
2002	200,824	81,359	271,602	23,434	66,043	18,121	78,203	61,100	830	1,529	1,121	3,475	5,202	812,843	23	7
2003	179,280	45,036	163,588	16,485	80,288	25,967	119,374	26,974	442	1,111	3,225	2,958	21,125	685,853	23	10
2004	170,778	46,151	229,866	40,889	107,601	12,787	94,880	8,931	1,202	1,985	1,906	4,125	30,146	751,247	23	9
2005	136,833	33,505	118,850	30,915	79,245	26,007	41,623	7,794	562	2,366	1,253	5,770	16,179	500,902	23	11
2006	129,708	49,500	136,690	38,438	83,731	7,953	22,388	1,483	360	2,870	5,666	6,048	54,190	539,025	23	12
2007	98,526	26,293	150,746	26,037	91,683	13,940	27,080	7,250	647	2,653	13,201	9,434	41,133	508,623	23	12
2008	145,069	17,230	109,813	13,804	14,780	8,971	31,244	4,138	151	1,235	3,202	2,773	6,335	358,745	21	11
2009	223,975	23,056	134,757	17,321	36,543	9,449	38,710	8,546	133	1,130	3,835	2,773	316	500,544	21	12
2010	191,547	34,160	182,174	14,729	43,988	3,867	19,193	20,990	313	563	3,145	3,157	3,975	521,801	20	11

Table 6. Yield of fishes in state-licensed outer Saginaw Bay commercial fishery. Yield in round Kilograms (Includes: large mesh and small mesh trapnets) 1986 – 2010. Other species include: burbot, carp, channel catfish, menominee, quillback, freshwater drum, sucker spp., white bass, yellow perch.

Year	Lake whitefish	Other	Total yield	# of outer bay licenses issued	# of inner bay licenses reporting no harvest
1986	20,649	4,684	25,334	2	2
1987	89,456	3,851	93,308	2	2
1988	96,205	7,125	103,330	2	2
1989	119,996	5,803	125,799	2	2
1990	118,538	635	119,173	2	2
1991	165,732	2,994	168,726	2	2
1992	221,482	2,839	224,321	2	2
1993	199,841	2,449	202,290	2	2
1994	186,939	1,314	188,253	2	2
1995	159,229	3,767	162,996	2	2
1996	152,822	442	153,264	2	2
1997	134,272	70	134,343	2	2
1998	112,232	117	112,348	2	2
1999	126,326	904	127,229	2	2
2000	132,458	80	132,538	2	2
2001	135,904	1,147	137,051	2	2
2002	163,492	1,930	165,422	2	2
2003	248,941	181	249,121	2	2
2004	273,466	1,435	274,901	2	2
2005	352,701	293	352,994	2	2
2006	423,834	2,105	425,939	2	2
2007	446,721	34	446,755	2	2
2008	444,680	792	445,472	2	2
2009	421,454	790	422,244	2	2
2010	307,234	1,149	308,383	2	2

Table 7. Liters of bait harvested by the commercial bait industry from Saginaw Bay, 2008-2010. Percent of the statewide bait harvest for each year is also shown.

Year	Emerald Shiners	Spottail Shiners	Suckers	Other Minnows	Total	% of Statewide
2008	54,215	4,028	38	114	58,394	58.2
2009	19,389	1,196	19	397	21,002	17.3
2010	55,880	4,119	4	625	60,627	6.2