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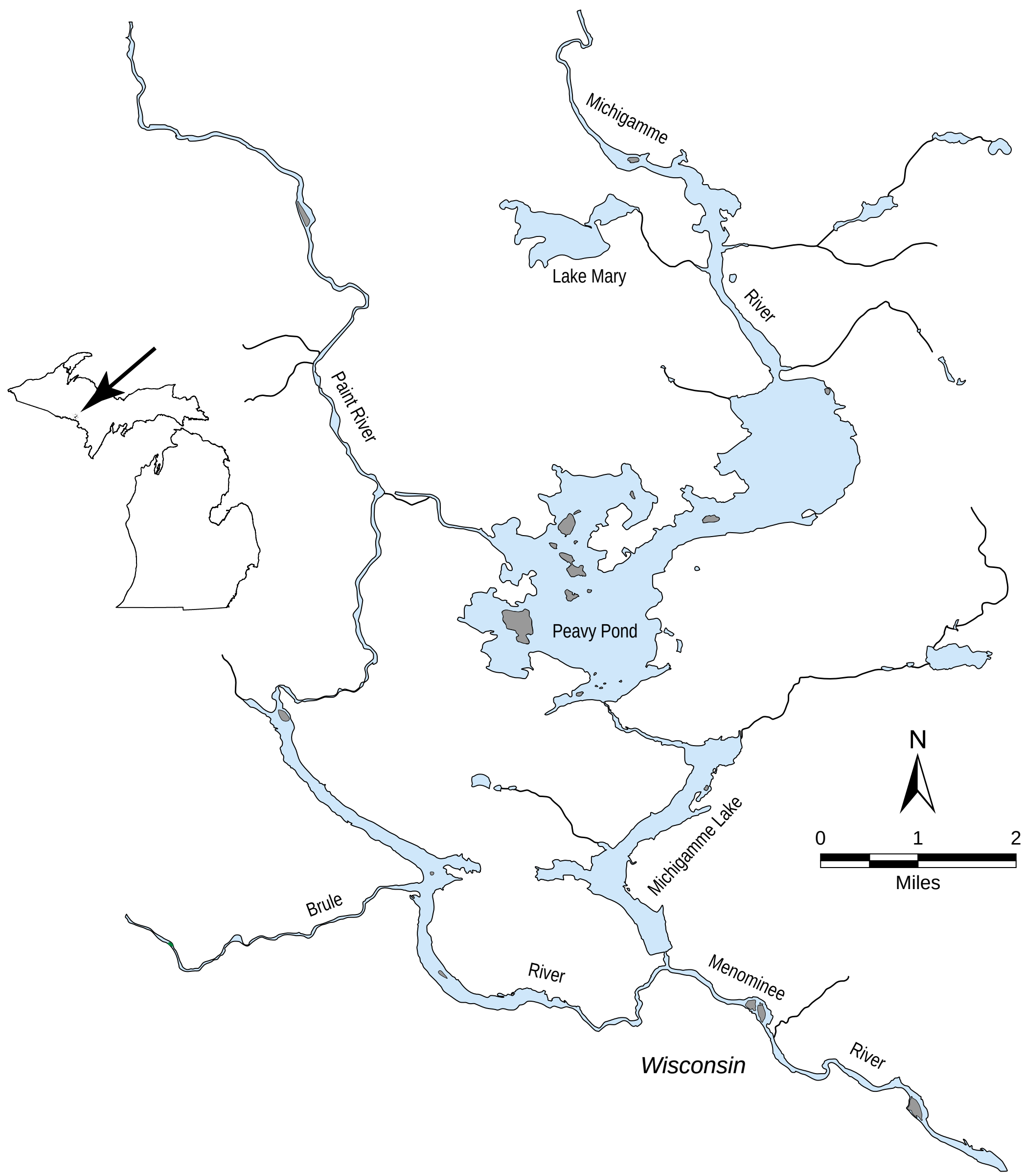
The Fish Community and Fishery of Peavy Pond, Iron County, Michigan with Emphasis on Walleye and Northern Pike

Patrick A. Hanchin



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Michigan Department of Natural Resources
Fisheries Special Report 57, 2011

The Fish Community and Fishery of Peavy Pond, Iron County, Michigan in 2004-05 with Emphasis on Walleye and Northern Pike

Patrick A. Hanchin

Michigan Department of Natural Resources, Charlevoix Fisheries Research Station,
96 Grant Street, Charlevoix, Michigan 49720

Introduction

The Michigan Department of Natural Resources (DNR), Fisheries Division surveyed fish populations and angler catch and effort at Peavy Pond, Iron County, Michigan from April 2004 through February 2005. This work was part of the Large Lakes Program, which is designed to improve assessment and monitoring of fish communities and fisheries in Michigan's largest inland lakes (Clark et al. 2004). The Large Lakes Program has three primary objectives. The first objective is to produce consistent indices of abundance and estimates of annual harvest and fishing effort for walleye *Sander vitreus*, northern pike *Esox lucius*, smallmouth bass *Micropterus dolomieui*, and muskellunge *Esox masquinongy*. Since these species support valuable fisheries, the second goal is to produce growth and mortality statistics to evaluate the effects of fishing on these species. This usually involves targeted sampling to collect, sample, and mark sufficient numbers of fish. The third goal is to evaluate the suitability of various statistical estimators for use in large lakes. For example, comparisons were made among four types of abundance and three types of exploitation rate estimators in this survey of Peavy Pond. The Large Lakes Program will maintain consistent sampling methods over lakes and time, which will allow the evaluation of differences in fish population and harvest statistics among lakes or changes within a lake over time. Peavy Pond was the fourteenth lake to be surveyed as part of the Large Lakes Program. However, since twenty lakes had been surveyed at the time the report was written, statistics from all surveyed lakes were used for comparison. The sample size for these types of comparisons varies throughout the report since some statistics could not be estimated for a lake and/or species.

Study Area

Peavy Pond is an impoundment of the Michigamme River in Iron County, Michigan. The impoundment was created in 1943 when the Wisconsin-Michigan Light and Power Company [name changed to Wisconsin Electric Power Company (WEPC) and later to WE Entergies] built Peavy Falls Dam. The purpose of the dam was to store spring runoff, and supplement low flows for power generation. The watershed of the reservoir is approximately 715 square miles. Reports of the reservoir surface area vary from source to source. Humphrys and Green (1962) estimated 2,673 acres, WEPC (1991) reported 2,794 acres at normal pool elevation (1,285.0 ft), WEPC (1999) reported 2,900 acres normal full surface area, and Breck (2004) reported 2,348 acres. The WEPC study examined satellite images taken on June 4, 1989 at normal pool elevation. Their methods provided spatial resolution of 65.6 ft, which resulted in the most accurate estimate of total surface area of 2,794 acres. In the Large Lakes Program, one goal is to compare various measures of productivity among lakes, such as number of fish per acre or harvest per acre, so an accurate measure of lake size is fairly important.

Therefore, I will use the 1989 Wisconsin Electric Power Company estimate of 2,794 acres as the size of Peavy Pond in analyses.

The Peavy Pond watershed is within the Western Upper Peninsula ecoregion (Eagle et al. 2005). This ecoregion is primarily forested (81%) and wetlands (11%), with some agricultural land (2%), urban land (2%), and a mix (4%) of grassland, shrubland, and alvar (limestone plain with thin soil and sparse vegetation). Forest types include northern hardwoods, aspen, pines, and lowland conifers. The geology of the region consists of igneous and metamorphic bedrock of the Precambrian Shield. Numerous exposures of Precambrian bedrock are found throughout the ecoregion. The ecoregion contains several extensive outwash plains, which contain soils of acidic sand and gravels that have little organic material. The relatively nutrient-poor, rocky, acidic soils result in waterbodies with generally low productivity.

The Reservoir is fed by the Michigamme and Paint rivers, and Parks, Davison, Camp Six, Larson, and Camp Five Creeks (Figure 1). The Paint River flows into Peavy Pond through a 1.4-mile man-made diversion canal. The current license requires a minimum flow of 85 cubic ft per second to the Paint River, with the remaining flow available for diversion to Peavy Pond (WEPC 1999). The Michigamme River flows out of Peavy Pond and into Michigamme Lake (also known as Michigamme Falls Reservoir) which flows into the Menominee River. Peavy Pond is connected to several small lakes (Mary, Erickson, Marsh, and Emerson) via its tributary systems, and to other large impoundments of the Michigamme and Paint rivers (Michigamme Reservoir, Michigamme Falls Reservoir, and Paint River Pond).

The water level of Peavy Pond is controlled by operation of Peavy Falls Dam. The dam is concrete, with a height of 96 ft, and normal operating head on the dam is approximately 95 ft (WEPC 1999). Maximum discharge is 15,500 cubic ft per second, and its normal storage capacity is 40,800 acre ft. Typically, the water level is managed on an annual cycle with minimum pool around 2,680 acres in the summer and 490 acres in the winter. The winter drawdown of 15 ft occurs from March 1 through May 15, which reduces volume by 80%. Summer fluctuation, occurring from May 16 through February 29, is 1 foot. At average pool, maximum depth of the reservoir is over 60 ft, occurring near the dam. However, the estimated average depth is 14 ft, which is highly influenced by the extensive shallow water in the western portion of the reservoir.

The reservoir has approximately 52 miles of undeveloped shoreline including islands, and 44 miles excluding the islands at full pool (WEPC 1999). Of the 52 shoreline miles, 47% has aquatic vegetation. Submerged aquatic vegetation is composed of *Vallisneria, Potamogeton, Polygonum, Najas, Ceratophyllum, Utricularia, Elodea*, and *Myriophyllum*. Riparian vegetation is a mix of pine, spruce, cedar, maple, oak, birch, basswood, and aspen, with an understory of grass, bracken, sweet fern, and Labrador tea (AVD Archaeological Services, Inc. 1998). Of the 44 shoreline miles excluding islands, 95% is owned by WEPC, and the remaining 5% is in private ownership. WEPC operates numerous rustic campsites around the reservoir. The aquatic habitat is diverse, including many shallow bays, wetlands, sandy shores, and large areas of open water. Most bays have primarily organic sediments, but sand, gravel, and rock are common along the shoreline. Aquatic vegetation is abundant and highly diverse throughout the reservoir. The reservoir thermally stratifies in the early summer, and dissolved oxygen levels can drop below 5 mg/L in the hypolimnion (WEPC 1999). This hypolimnetic water can extend to within 18 ft of the surface during the warmest days of the summer.

The fish community of Peavy Pond includes species typical of mesotrophic reservoirs in this northern, forested region. Families of fish include, but are not limited to *Catostomidae, Centrarchidae, Cottidae, Cyprinidae, Esocidae, Gadidae, Ictaluridae, Percidae*, and *Salmonidae (including subfamily Coregoninae)*. Fish have never been stocked in Peavy Pond. There have been fifteen State of Michigan Master Angler awards taken from Peavy Pond from 1990-2006, including six black crappie, two bluegill, one burbot, two muskellunge, two northern pike, and two smallmouth bass.

Methods

Fish populations in Peavy Pond were sampled with fyke nets and electrofishing gear from April 15 to May 5, 2004. Three to four boats were used daily, each with a three-person crew. One or two of the crews electrofished in the Michigamme and Paint rivers, and one or two crews tended nets in Peavy Pond. Fyke nets were 6 ft x 4 ft with 3/4-in stretch mesh and 70- to 100-ft leads. Nets were located to target walleye and northern pike (nonrandom), though efforts were made to cover the entire reservoir. Duration of net sets ranged from 1–2 nights, but most were 1 night. Crews used a Smith-Root® boat equipped with boom-mounted electrodes (DC) for electrofishing. Only target species (walleye and northern pike) were collected during electrofishing. Latitude and longitude were recorded for all net locations and electrofishing runs using hand-held global positioning systems (GPS). In addition to the spring survey a standardized (Wehrly et al. In press) survey was conducted from June 14 – July 13 using fyke nets, trap nets, 125-ft experimental gill nets (25-ft panels of 1.5-, 2.0-, 2.5-, 3.0, and 4.0-in mesh), seines, and electrofishing gear.

Fish Community

The status of the overall fish community was analyzed and described in terms of species present, catch per unit effort, percent by number, and length-frequencies. Lengths of nontarget species were measured to the nearest 0.1 in for subsamples of up to 200 fish per work crew. Crews ensured that lengths were taken over the course of the survey to account for any temporal trends in the size structure of fish collected. I used a Microsoft Access© computer database to store and retrieve data collected during the tagging operation. I calculated mean catch per unit effort (CPUE) in fyke nets as an indicator of relative abundance, utilizing the number of fish per net night (including recaptures) for all net lifts that were determined to have fished effectively (i.e., without wave-induced rolling or human disturbance). The percentages were calculated by number of fish collected in each of three feeding guilds: 1) species that are primarily piscivores; 2) species that are primarily pelagic planktivores and/or insectivores; and 3) species that are primarily benthivores. These indices will be used to compare fish communities among lakes or within the same lake over time, especially in the future when more large lake surveys using similar methods are available for comparison. Of the species collected, I classified walleye, northern pike, smallmouth bass, largemouth bass, muskellunge, and burbot as piscivores; rock bass, bluegill, pumpkinseed, yellow perch, black crappie, golden shiner, common shiner, creek chub, and brook trout as pelagic planktivores-insectivores; and tadpole madtoms, white suckers, black bullheads, lake whitefish, and mottled sculpin as benthivores.

Walleye and Northern Pike

Size structure and sex ratio.–In order to assess the size structure of the populations, the total lengths of all walleyes and northern pike were measured to the nearest 0.1 in on their initial capture. Walleyes and northern pike with flowing gametes were identified as male or female; fish with no flowing gametes were identified as unknown sex.

Abundance.–I estimated the abundance of adult and legal-size walleyes and northern pike greater than or equal to 18 in using mark-and-recapture methods. In the absence of a minimum size limit for northern pike on Peavy Pond, I assumed that 18 in was the minimum size acceptable to some anglers. Adult fish were defined as those greater than legal-size, or less than legal-size, but of identifiable sex by the extrusion of gametes. Legal-size walleyes (≥15 in) and northern pike greater than 18 in were fitted with monel-metal jaw tags. To assess tag loss, tagged fish were double-marked by clipping the left pelvic fin. Reward ($10) and nonreward tags were applied in an approximate 1:1 ratio. Large tags (size 16) that were used on large northern pike (≥36 in) were all nonreward. Initial tag loss was assessed during the marking period as the proportion of recaptured fish of legal size without tags. This tag loss was largely caused by entanglement with nets, and thus was not used to adjust estimates of abundance or exploitation. Newman and Hoff (1998) reported similar netting-induced tag loss. All fish that lost tags during netting recapture were re-tagged, and were accounted for in the total number of marked fish at large.

I used two different methods for estimating abundance from mark-and-recapture data, one derived from marked-unmarked ratios during the spring survey (multiple census) and the other derived from marked-unmarked ratios from the angler survey (single census). The Schumacher-Eschmeyer formula was used for the multiple-census estimates for daily recaptures during the tagging operation (Ricker 1975):

$$N = \frac{\sum_{d=1}^{n} C_d M_d^{\,2}}{\sum_{d=1}^{n} R_d M_d}$$

N = multiple-census population estimate (number of legal or adult fish)

C_d = U_d + R_d = total number of fish caught during day *d; U_d* = number of unmarked fish caught during day *d; R_d* = number of recaptures during day *d*

M_d = number of marked fish available for recapture at start of day *d*; and *d* = day (ranging from d_1 to d_n)

The variance formula was,

$$Var(N) = \frac{\sum_{d=1}^{n}\left(\frac{R_d^{\,2}}{C_d}\right) - \left[\frac{\left(\sum_{d=1}^{n} R_d M_d\right)^2}{\sum_{d=1}^{n} C_d M_d^{\,2}}\right]}{m-1},$$

where *m* = number of days in which fish were actually caught.

Variance of 1/*N* is:

$$\frac{Var(N)}{\sum_{d=1}^{n} C_d M_d^{\,2}}.$$

The minimum number of recaptures necessary for an unbiased estimate was set a priori at four. Asymmetrical 95% confidence intervals were computed as:

$$\frac{1}{\frac{1}{N} \pm t(\sigma)}$$

For the single-census estimates, the recapture sample was comprised of the number of marked and unmarked fish observed by creel clerks in the companion angler survey, and by technicians during the standard summer netting survey of Peavy Pond. I used the Chapman modification of the

Petersen method to generate population estimates and the minimum number of recaptures necessary for an unbiased estimate was set a priori at three (Ricker 1975):

$$N = \frac{(M+1)(C+1)}{R+1},$$

N = single-census population estimate (numbers of legal-sized fish)

M = number of fish caught, marked and released in first sample

C = total number of fish caught in second sample (unmarked + recaptures)

R = number of recaptures in second sample

I calculated the variance as:

$$Var(N) = \frac{N^2(C-R)}{(C+1)(R+2)},$$

Asymmetrical 95% confidence limits were calculated using values from the Poisson distribution for the 95% confidence limits on the number of recaptured fish (R), which were substituted into the equation for N above (Ricker 1975). Estimated numbers of adult walleyes and northern pike from the single-census estimates were calculated by dividing the estimates for legal-size fish by the proportion of legal-size fish on the spawning grounds, using the formula:

$$N_a = \frac{N_{leg} + N_{sub}}{N_{leg}} \times N,$$

N_a = estimated number of adult walleyes or northern pike

N_{sub} = number of sublegal and mature fish (<15 in for walleye or <18 in for northern pike) caught

N_{leg} = number of legal fish caught; N = single-census estimate of legal-size walleyes or northern pike

I calculated the variance as:

$$Var(N_a) = \left(\frac{N_{leg} + N_{sub}}{N_{leg}}\right)^2 \times Var(N).$$

There was one prior estimate of adult walleye abundance made in 1997 for Peavy Pond and the Lower Paint Reservoir combined (Mead and Hunt, Inc. 1997) that helped gauge how many fish to mark. They used a multiple-census method (Schnabel) based on netting and electrofishing from ice-out through late June. Their estimate of 10,488 adult walleyes can be approximately split between Peavy Pond (9,350) and the Lower Paint Reservoir (1,138) by comparing the fractional surface area of the two reservoirs (2,794 and 340 acres, respectively). The authors noted fish movement throughout different parts of the study area, and thus pooled the mark-recapture data for a single estimate.

In addition to the empirical estimate, I used three regression equations, one developed from Wisconsin lakes (Hansen and Hennessy 2006) and two from Michigan lakes (DNR unpublished data), to provide initial estimates of walleye abundance. These regressions predict legal size or adult walleye abundance based on lake size and were derived from historic abundance estimates made in each state over the past 20–25 years. The following equation for adult walleyes in Michigan was based on 31 abundance estimates:

$$\ln(N) = 0.3710 + 1.0461 \times \ln(A),$$

$$R^2 = 0.80, \qquad P < 0.0001,$$

where N is the estimated number of adult walleyes and A is the surface area of the lake in acres. For Peavy Pond, the equation gives an estimate of 5,838 adult walleyes, with a 95% prediction interval (Zar 1999) of 1,111 to 30,682. The equation for adult walleyes in the Treaty-ceded territory of Wisconsin was based on 185 estimates:

$$\ln(N) = 01.5923 + 0.9489 \times \ln(A),$$

$$R^2 = 0.56, \qquad P < 0.0001,$$

where N is the estimated number of adult walleyes and A is the surface area of the lake in acres. The equation gives an estimate of 9,157 walleyes, with a 95% prediction interval (Zar 1999) of 3,010 to 27,855 for Peavy Pond. The equation for legal walleyes in Michigan was based on 32 estimates:

$$\ln(N) = 0.5423 + 0.9794 \times \ln(A),$$

$$R^2 = 0.74, \qquad P < 0.0001,$$

where *N* is the estimated number of legal walleyes and *A* is the surface area of the lake in acres. The equation gives an estimate of 4,082 legal walleyes, with a 95% prediction interval (Zar 1999) of 884 to 18,862 for Peavy Pond. Based on these a priori abundance estimates, I thought that marking a minimum of 500 legal-size walleyes, or 900 adult walleyes (≈10% of the population) would be sufficient. A specific tagging goal for northern pike was not determined, but rather crews tagged as many as possible until the walleye goal was achieved.

For the single-census estimate, fish that recruited to legal size during the angler survey were accounted for based on the estimated weighted average monthly growth for fish of slightly sublegal size. That is, because estimates were for the abundance of legal-sized fish at time of marking (spring) and growth of fish occurred during the recapture period, it was necessary to reduce the number of unmarked fish used in the formula by the estimated number that recruited to legal size during the recapture period. For example, to make this adjustment for walleye the annual growth of slightly sublegal fish (i.e., 14.0 - 14.9 in fish) was determined from mean length-at-age data. This value was then divided by the length of the growing season in months (6) and rounded to the nearest 0.1 in. This average monthly growth was used as the criteria to remove unmarked fish that were observed in the angler survey. The largest size of a sublegal fish at tagging was 14.9 in; thus, an average monthly growth of 0.2 in would result in all unmarked fish 15.1 in or smaller caught during the first full month (June) after tagging to be subtracted from the total number of fish caught in second sample (C). Adjustments were made for each month of the creel survey resulting in a final ratio of marked to unmarked fish. This final ratio was used to make the single-census population estimate. I calculated the coefficient of variation (CV) for each abundance estimate (single- and multiple-census) as the standard deviation divided by the point estimate and considered estimates with a CV less than or equal to 0.40 to be reliable (Hansen et al. 2000).

Growth.–Dorsal spines were used to age walleyes and dorsal fin rays to age northern pike because they provided a good combination of ease of collection in the field and accuracy and precision of age estimates. Although otoliths have been shown to be the most accurate and precise ageing structure for older walleyes (Heidinger and Clodfelter 1987; Koscovsky and Carline 2000; Isermann et al. 2003) and otoliths or cleithra for northern pike (Casselman 1974; Harrison and Hadley 1979), collecting these structures would have required killing the fish, which would greatly reduce the number of marked fish at large. Additionally, since there is not consensus on the accuracy and precision of spines versus scales (Belanger and Hogler 1982; Campbell and Babaluk 1979; Erickson 1983; Kocovsky and Carline 2000; Isermann et al. 2003), I decided to use spines since they likely provide more accurate ages for the oldest fish in the populations. Accurate ages for older fish were important to estimate mortality for the populations. Studies have demonstrated that fin rays are a valid aging structure for a number of species (Skidmore and Glass 1953; Ambrose 1983), including northern pike (Casselman 1996), but no comparisons have been made to statistically compare accuracy and precision of fin rays to other aging structures for northern pike. Sample size goals were 20 male and 20 female fish per inch group for walleye and northern pike. Unfortunately, numerous recording errors regarding the sex of spine and fin ray samples taken in the field prohibited the separation of various estimates (mean lengths-at-age, mortality) by sex.

Dorsal spines and fin rays were prepared by sectioning samples using a table-mounted high-speed rotary cutting tool. Sections approximately 0.02-in thick were cut as close to the proximal end of the spine or ray as possible. Sections were examined at 40x-80x magnification with transmitted light and were photographed with a digital camera. The digital image was archived for multiple readers. Two technicians independently aged samples, and ages were considered final when independent estimates were in agreement. Samples in dispute were aged by a third technician. Disputed ages were considered final when the third technician agreed with one of the first two. Samples were discarded if three technicians disagreed on age, though occasionally an average age was used when ages assigned to older fish (≥ age 10) were within ±10% of each other.

After a final age was identified for all samples, I calculated weighted mean lengths-at-age and age-length keys (Devries and Frie 1996) for walleye and northern pike. I compared the mean lengths-at-age to those from previous surveys of Peavy Pond and to other large lakes. I also computed a mean growth index to compare the data to Michigan state averages, as described by Schneider et al. (2000a). The mean growth index is the average of deviations (by age group) between the observed mean lengths and statewide seasonal average lengths. In addition, I fit mean length-at-age data to a von Bertalanffy growth equation using nonlinear regression, and calculated the total length at infinity (L_∞) for use as an index of growth potential. All growth curves were forced through the origin.

Mortality.–Mortality rates for walleye and northern pike were calculated using catch-curve analyses with assumptions described by Ricker (1975). The goal was to estimate total mortality for fish of legal size for comparison with fishing mortality, which was only estimated for fish of legal size. When choosing age groups to be included in the analyses, I considered several potential problems. First, an assumption of catch-curve analysis is that the mortality rate is uniform with age over the full range of age groups in analysis. Fish were collected with gears different from those used in the fisheries and the size (age) of recruitment in the fisheries was controlled by minimum-size-limit regulations. For fish smaller than the minimum size limit, mortality is M+H; for larger fish, mortality is M+H+F, where M, H, and F are natural, hooking (from catch and release), and fishing mortality, respectively. Thus, from the standpoint of uniformity in mortality, age groups used in a single catch curve should contain fish that are either all smaller than, or all larger than the minimum size limit in the fishery, or the minimum size acceptable to anglers in the absence of a minimum size limit. Although walleye and northern pike exhibit sexual dimorphism (Carlander 1969, 1997), which could lead to differences in mortality between sexes, I could not compute separate catch curves for males and females due to the aforementioned data recording errors. Finally, walleyes and northern pike were collected in the act of spawning, so I had to be sure that fish in each age group were sexually mature and represented on the spawning grounds in proportion to their true abundance in the population. Thus, only age groups with fish that were judged to be mostly mature were included in the analyses. I based this judgment on a combination of information, including relative abundance and mean size by age and percent maturity by size.

I estimated angler exploitation rates using three methods: 1) the percent of reward tags returned by anglers; 2) the estimated harvest divided by the multiple-census estimate of abundance; and 3) the estimated harvest divided by the single-census estimate of abundance. Probability of tag loss was calculated as the number of fish in the recapture sample that had lost tags (fin clip and no tag) divided by all fish in the recapture sample that had been tagged, including fish that had lost their tag. Standard errors were calculated assuming a binomial distribution (Zar 1999). In the first method, exploitation rate was estimated as the fraction of reward tags returned by anglers, adjusted for tag loss. I made the assumption that mortality was negligible and that near 100% of reward tags on fish caught by anglers would be returned. Tag returns were encouraged with a monetary reward ($10) denoted on approximately 50% of the tags. Tag return forms were made available at boater access sites, at DNR offices, and from creel clerks. Additionally, tag return information could be submitted on-line at the DNR website. All tag return data were entered into the database so that they could be efficiently linked to and verified against data collected during the tagging operation. Linked documents were developed with Microsoft Word® software so that payment vouchers and letters to anglers were automatically produced with relevant information from the database. Letters were sent to all anglers with information on the length and sex of the tagged fish, and the location and date of tagging. Return rates were calculated separately for reward and nonreward tags. The reporting rate of nonreward tags relative to reward tags (λ in Pollock et al. 1991) was calculated as an indicator of nonreporting. Since I was also interested in knowing the sizes of northern pike that anglers harvest and/or release in the absence of a minimum size limit, I calculated separate exploitation rates by inch group. Minimum sample size (number tagged) was set at 100 for each inch group, with the intention of combining inch groups that did not meet the minimum sample size into a “plus” group (i.e., 24 in and above). Although I did not truly assess nonreporting, I did compare the actual number of tag returns to the expected number (X) based on the ratio:

$$\frac{N_t}{N_C} = \frac{X}{H}$$

Nt = Number of tags observed in creel
Nc = Number of fish observed in creel
H = Total expanded harvest of species

I also checked individual tags observed by the creel clerk to see if they were subsequently reported by anglers; however, this was not a true estimate of nonreporting because there was the possibility that anglers believed the necessary information was obtained by the creel clerk during the interview, and further reporting to the DNR was unnecessary. In addition to data on harvested fish, I estimated the release rate of legal-size fish as the percentage of positive responses to a question on the tag return form asking if the fish was released. I also calculated release rates by inch group for northern pike, using the aforementioned sample size requirements.

In the second and third methods, I calculated exploitation as the estimated annual harvest from the angler survey divided by the multiple- and single-census abundance estimates for legal-sized fish. For proper comparison with the single-census abundance of legal fish as existed in the spring, the estimated annual harvest was adjusted for fish that would have recruited to legal size over the course of the creel survey based on the percentage of fish observed in the creel survey that were determined to have been sublegal at the time of the spring survey (See *Abundance* subsection of the *Methods* section). I calculated 95% confidence limits for these exploitation estimates assuming a normal distribution, and summing the variances of the abundance and harvest estimates.

Recruitment.–I considered relative year-class strength as an index of recruitment, and used the residuals from the catch-curve regressions as indices of year-class strength (Maceina 2003).

Relationships among year-class strength and various environmental variables were evaluated by use of correlation analyses. The significance levels ($\alpha = 0.10$) were adjusted with a Bonferroni correction of alpha for multiple comparisons (Sokal and Rohlf 1995) to limit overall experimentwise error. Historic weather data were obtained from the nearest National Weather Service observation station with complete records for the time series (Stambaugh, MI, station 207812). Water elevation data for Peavy Falls Dam were provided by WEPC. I did not have any historic water quality data specific to the lake so analyses were limited to correlation with weather data. Variables tested included: monthly minimum and maximum air temperature, average monthly air temperature, total monthly precipitation, and monthly minimum, maximum, and average water elevation.

Movement.–Fish movements were assessed in a descriptive manner by examining the location of angling capture versus the location of initial capture at tagging. Capture locations provided by anglers were often vague; thus, statistical analysis of distance moved would be questionable. Instead, I identified conspicuous movement, such as to another lake or connected river. The Peavy Pond system was divided into four sections for the purposes of tagging and tag recaptures— Peavy Pond, North Michigamme River (from highway M-69 to Hemlock Dam), South Michigamme River (from Peavy Pond to highway M-69), and the Paint River and diversion canal (Figure 1).

Angler Survey

Direct contact angler creel surveys were conducted during the open-water period – May 8 through October 31, 2004, and the ice-cover period – December 16, 2004 through February 28, 2005. Fishing harvest seasons during the angler survey were May 15, 2004 through February 28, 2005 for walleye and northern pike, and May 29 through December 31, 2004 for smallmouth bass and largemouth bass. Minimum size limits were 15 in for walleyes, 14 in for smallmouth and largemouth bass, 42 in for muskellunge, and there was no minimum size limit for northern pike. Daily bag limit was five fish in any combination of walleye, northern pike, smallmouth bass, or largemouth bass, and one for muskellunge. Harvest was permitted all year for other species present and no minimum size limits were imposed. The bag limit for yellow perch was 50 per day and for "sunfishes", including black crappie, bluegill, pumpkinseed, and rock bass it was 25 per day in any combination. The bag limit for lake whitefish and lake herring was 12 in combination.

Field methods.–The angler survey utilized a progressive-roving design for both the open-water and ice-cover periods (Lockwood 2000b). One clerk working from a boat or snowmobile collected angler interview data and counted fishing boats, or open-ice anglers and occupied shanties. Both weekend days and three randomly determined weekdays were selected for counting and interviewing during each week of the survey season. No holidays were sampled. The starting location (points 1-7) and direction (clockwise or counter-clockwise) for counts were randomized (Figure 2). Time of count was randomized to cover daylight times within the sample period. Minimum fishing time prior to interview (incomplete-trip interview) was 1 h (Lockwood 2004, Clark et al. 2004). Roving interview data were collected for individual anglers to avoid party size bias (Lockwood 1997), though the number of anglers in each party was recorded on one interview form for each party. While this survey was designed to collect roving interviews, the clerk occasionally encountered anglers as they completed their fishing trips. The clerk was instructed to interview these anglers and record the same information as for roving interviews – noting that the interview was of a completed trip. Interview information collected included: date, fishing mode, start time of fishing trip, interview time, species targeted, bait used, number of fish harvested by species, number of fish caught and released by species, length of harvested walleyes, northern pike, and smallmouth bass, and applicable tag number. One of two shifts was selected each sample day for interviewing (Table 1).

Estimation methods.–Estimates of angler catch and effort were made using a multiple-day method (Lockwood et al. 1999). Expansion values ("F" in Lockwood et al. 1999) are the number of hours within sample days (Table 1). Effort is the product of mean counts for a given period day type, days within the period, and the expansion value for that period. Thus, the angling effort and catch reported are for those periods sampled, no expansions were made to include periods not sampled (e.g., 0100 to 0400 hours). Most interviews (>80%) collected during summer and winter survey periods were of a single type (access or roving). However, during some shorter periods (i.e., day type within a month) fewer than 80% of interviews were of a single type. When 80% or more of interviews within a time period (weekday or weekend day within a month) were of an interview type, the appropriate catch-rate estimator for that interview type (Lockwood et al. 1999) was used on all interviews. When less than 80% were of a single interview type, a weighted average R_w was used:

$$R_w = \frac{\left(\hat{R} \cdot n_1\right) + \left(\overline{R} \cdot n_2\right)}{\left(n_1 + n_2\right)},$$

where $\hat{R}$ is the ratio-of-means estimator for n1 completed-trip interviews and $\overline{R}$ the mean-of-ratios estimator for n_2 incomplete-trip interviews. Estimated variance s_w^2 was calculated as:

$$s_w^2 = \frac{\left(s_{\hat{R}}^2 \cdot n_1^2\right) + \left(s_{\overline{R}}^2 \cdot n_2^2\right)}{\left(n_1 + n_2\right)^2},$$

where $s_{\hat{R}}^2$ is the estimated variance of $\hat{R}$ and $s_{\overline{R}}^2$ is the estimated variance of $\overline{R}$.

Angler effort was estimated in terms of both angler hours and angler trips. An angler trip is defined as the period an angler is at a lake (fishing site) and actively fishing. When an angler leaves the lake or stops fishing for a significant period of time (e.g., an angler leaving the lake to eat lunch), the trip has ended. Movement between fishing spots, for example, was considered part of the fishing trip. Mail or telephone surveys typically report angling effort as angler days (Pollock et al. 1994). Angler trips differ from angler days because multiple trips can be made within a day. Historically, Michigan angler creel data average 1.2 trips per angler day (DNR Fisheries Division – unpublished data).

All estimates (±2 SE) from the angler survey provided statistical significance of 75 to 95% assuming a normal distribution and sufficient sample size (N ≥ 10) (Dixon and Massey 1957). All count samples exceeded minimum sample size (10) and effort estimates approximated 95% confidence limits. Most error bounds for catch and release, and harvest estimates also approximated 95% confidence limits. However, coverage for rarely caught species is more appropriately described as 75% confidence limits due to severe departure from normality of catch rates.

Results[1]

Fish Community

A total of 12,837 fish comprised of 21 species were collected (Table 2) from a total sampling effort of 399 fyke-net lifts and 54 electrofishing runs. Yellow perch were the most numerous species collected, comprising 36% of the catch by number, with a mean length of 6.2 inches. The total catch included 2,509 walleyes and 3,310 northern pike, which made up approximately 20% and 26% of the total catch,

[1] Confidence limits for estimates are provided in relevant tables, but not in the text.

respectively. Other fish species collected in order of decreasing abundance were: tadpole madtoms, rock bass, bluegill, white sucker, black crappie, pumpkinseed, smallmouth bass, muskellunge, burbot, golden shiner, common shiner, creek chub, lake whitefish, mottled sculpin, largemouth bass, black bullhead, brook trout, and tiger muskellunge. Of interest was the abundance of tadpole madtoms, which comprised 7% of the total catch. The overall fish community composition in Peavy Pond was 46% piscivores, 45% pelagic planktivores-insectivores, and 9% benthivores (Table 2).

Walleye and Northern Pike

Size structure and sex ratio.–The percentage of legal-size walleyes and northern pike 18 in or larger was 53 and 53, respectively (Table 3). The percentage of northern pike greater than the statewide minimum length limit (24 in) was 4. The population of spawning walleyes was dominated by 12- to 20-in walleyes, with relatively few greater than 21 in. The population of spawning northern pike was dominated (86% of total catch) by 14- to 23-in fish, though the distribution extended to 38 inches. Large pike (≥30 in) were present, although they made up only 1% of the catch. Male walleyes outnumbered females in the spring survey, though an exact ratio could not be determined. Males typically outnumber females in surveys of spawning walleyes (Carlander 1997). The sex ratio of northern pike was approximately 1:1, though an exact ratio was also not possible due to the aforementioned data recording errors.

Abundance.–Valid multiple- and single-census abundance estimates were obtained for both walleyes and northern pike in Peavy Pond. Crews placed a total of 1,107 tags on legal-size walleyes (565 reward and 542 nonreward tags) and in total marked (with jaw tag or fin clip) 1,839 adult walleyes. Two recaptured walleye died, and eight lost their tag during the spring netting survey; thus, the effective number tagged (M) was 1,097. Since most short-term tag loss was due to the netting process, short-term tag loss rates were not calculated. The angler survey clerk observed a total of 212 walleyes on Peavy Pond, of which 45 were marked (R; had a fin clip, or a tag). The initial C was reduced by 42 (19.8%) to adjust for sublegal fish that grew over the minimum size limit during the fishing season (final C = 170). The estimated number of legal-size walleyes was 2,614 using the multiple-census method and 4,082 using the single-census method (Table 4). The estimated number of adult walleyes was 6,011 using the multiple-census method, and 6,753 using the single-census method. The coefficient of variation was 0.07 for the multiple-census estimate of legal-size walleyes, was 0.09 for the multiple-census estimate of adult walleyes, and was 0.12 for both of the single-census walleye estimates. For both of the multiple-census estimates, the minimum number of recaptures was obtained, and the estimates were considered reliable based on the CV. For the single-census estimates, there were sufficient numbers of fish marked and observed for marks to achieve an ideal level of precision. Assuming that the legal walleye population was approximately 4,000 fish (single-census estimate), and based on tagging 1,097 fish, the recommended recapture sample to observe for marks in management studies (α = 0.05, P = 0.25; where P denotes the level of accuracy, and 1-α the level of precision) is 177 fish (Robson and Regier 1964). The corrected recapture sample of 170 fish was about equal to this recommendation.

Valid abundance estimates for northern pike were calculated, though an ideal level of precision was not achieved for the single-census estimates. Crews tagged 1,222 northern pike greater than or equal to 18 inches in Peavy Pond (585 reward and 637 nonreward tags) and in total marked (with jaw tag or fin clip) 2,245 adult northern pike. Forty-two recaptured northern pike lost their tag during the spring netting; thus, the effective number tagged (M) was 1,180. The creel clerk observed 128 northern pike, of which 32 were marked (R; had a fin clip, or a tag). The initial C was reduced by 32 (25%) to adjust for sublegal fish that grew over the minimum size limit during the fishing season (final C = 96). The estimated number of northern pike ≥ 18 inches was 2,054 (CV = 0.06) using the multiple-census method, and was 3,471 (CV = 0.14) using the single-census method. The estimated number of adult northern pike was 4,740 (CV = 0.06) using the multiple-census method and 6,336 (CV = 0.14) using the single-census method (Table 4). The single-census estimates did not achieve the ideal level of precision since the recapture sample was not high enough. Assuming that the population of 18-in northern pike was approximately 4,000 fish, and based on tagging 1,180 fish, the recommended recapture sample in management studies (α = 0.05, P = 0.25; where P denotes the level of accuracy, and 1-α the level of precision) is 160 fish (Robson and Regier 1964). The corrected recapture sample observed by the creel clerk (96 fish) was short of this recommendation. However, even though the ideal level of precision was not achieved, given the methodological biases known about multiple-census estimates (Pierce 1997), I consider the single-census estimates to be more reliable. Pierce (1997) considered his multiple-census estimates of northern pike abundance as minimums, with the true abundances likely higher. Since the multiple-census estimates of both legal-size and adult northern pike abundance in Peavy Pond were lower than the single-census estimates, I am more comfortable with the higher of the two.

Growth.–Division technicians aged 368 walleyes and 496 northern pike (Table 5). Overall, walleye and northern pike in Peavy Pond grow slower than average populations in Michigan. The mean growth index for walleye was -2.6. Walleye mean lengths-at-age were equal to the statewide average for age 1, but negative deviations increased for ages 2 through 8 (Table 6). Age-8 walleyes were 4.3 inches lower than the statewide average. Mean length-at-age data fit to a von Bertalanffy growth curve produced an L_∞ value of 21.2 inches. The overall mean growth index for northern pike was -1.9. Mean lengths-at-age were lower than the statewide average for ages 1 through 7, but age-8 northern pike had higher mean lengths-at-age than the statewide average (Table 7). Northern pike mean length-at-age data fit to a von Bertalanffy growth curve resulted in an L_∞ value of 44.2 inches.

Agreement among readers for aging walleye spines was within the range observed in other studies. For walleye spine samples, there was 57% agreement between the first two spine readers. For fish that were aged by a third reader (and not discarded), agreement was with first reader 12% of the time and with second reader 88% of the time; thus, there appeared to be considerable bias among readers. Nine percent of samples were discarded due to poor agreement, and an average age was used 2% of the time. At least two out of three readers agreed 89% of the time. The average agreement between the first two readers of walleye spines from 18 Large Lake Program surveys in Michigan was 59%, while reader agreement from Isermann et al. (2003) and Kocovsky and Carline (2000) ranged from 55% to 63%. For northern pike fin ray samples, there was 83% agreement between the first two fin ray readers. For fish that were aged by a third reader (and not discarded), agreement occurred with the first reader 42% of the time and with the second reader 58% of the time; thus, there appeared to be little bias among readers. Two percent of samples were discarded due to poor agreement, thus at least two out of three readers agreed 98% of the time. Reader agreement for aging northern pike fin rays was above average when compared to other lakes. The average agreement between the first two readers of northern pike fin rays from 17 large lakes in Michigan is 73%.

Mortality.–For walleye, I apportioned the aged subsample to 2,093 fish (Table 8), which differs slightly from the number of unique walleyes measured (Table 2) as a result of rounding in the age-length key. I used ages 5 and older in the catch-curve analyses to represent the legal-size walleye population (Figure 3). I selected age 5 as the youngest age because: 1) average length of walleyes at age 5 was greater than legal size, so likely most age-5 fish were legal size at the beginning of fishing season; and 2) relative abundance of fish younger than age 5 did not appear to be represented in proportion to their expected abundance (Figure 3; Table 8). The catch-curve regression ($P < 0.05$) produced a total instantaneous mortality rate for legal-size fish of 0.583 (Figure 3), which corresponds to an annual mortality rate of 44%.

Anglers returned a total of 185 tags (102 reward and 83 nonreward) from harvested walleyes, and 10 tags (5 reward and 5 nonreward) from released walleyes in the Peavy Pond system in the year following tagging (Table 9). The majority (93%) of walleye tag returns were reported from the open-water portion of the angling year (Table 9). The creel clerk observed one (of 45) recaptured walleyes that had lost tags during the creel survey; thus, the estimated tag loss rate was 2.2%. The reward tag return estimate of annual exploitation of walleyes was 18.7% after adjusting for tag loss (Table 4). The estimated exploitation rate for walleyes was 24.2% based on dividing harvest by the multiple-census abundance estimate, and 15.5% based on dividing harvest by the single-census creel survey abundance estimate (Table 4).

Anglers reported reward tags at a higher rate than nonreward tags (19.2% versus 16.3%). Clark et al. (2004) used the same tags and reward amount in Houghton Lake and did not observe much difference in return rates of reward and nonreward tags. However, in Michigamme Reservoir, there was a large difference in reporting rates, and the authors believed that anglers returned nearly 100% of reward tags (Hanchin et al. 2005a). The reporting rate of nonreward tags relative to reward tags (λ in Pollock et al. 1991) was 84.2%, which is near the average (82%) from other walleye populations surveyed in the Large Lakes Program. There was obviously nonreporting of nonreward tags, but there was no way to derive a true estimate of the nonreporting rate for reward tags. The creel clerk did not observe any tagged fish in the possession of anglers that were not subsequently reported to by the anglers. There was evidence that overall reporting was good since that the number of tags voluntarily returned by anglers (185) exceeded the expected number of returns (168) based on the ratio described previously in the Methods section. Based on all tagged walleyes known to be caught, the reported release rate was 5.1%, which was the highest observed thus far in Large Lake surveys ($N = 11$). The mean and median values for release rates thus far are 2.1% and 1.5%, respectively.

For northern pike, I apportioned the aged subsample to 2,335 fish (Table 8). I used ages 3 and older in the catch-curve analyses to represent the adult northern pike population (Figure 4). I selected age 3 as the youngest age because: 1) average length of northern pike at age 3 was greater than the size I considered acceptable to anglers, so likely most age-3 fish were of acceptable size at the beginning of fishing season; and 2) relative abundance of fish younger than age 3 did not appear to be represented in proportion to their expected abundance (Figure 4; Table 8). The catch-curve regression ($P < 0.05$) produced a total instantaneous mortality rate for adult northern pike of 0.830 (Figure 4), which corresponds to an annual mortality rate of 56%.

Anglers returned a total of 124 tags (62 reward and 62 nonreward) from harvested northern pike, and 99 tags (61 reward and 38 nonreward) from released northern pike in the Peavy Pond system in the year following tagging (Table 9). The creel clerk also observed 4 tagged fish (1 reward and 3 nonreward) in the possession of anglers that were not subsequently reported to the DNR by the anglers. Overall, I found evidence that reporting was good in that the number of tags voluntarily returned by anglers exceeded the expected number of returns (120). All (100%) northern pike tag returns were reported from the open-water portion of the angling year. The clerk observed 3 (of 32) recaptured northern pike that had lost tags during the creel survey; thus, the estimated tag loss rate was 9.4%. The tag return estimate of northern pike exploitation was 12.5% after adjusting for tag loss (Table 4). Angler exploitation of northern pike increased with increasing length (Figure 5). The exploitation rate increased from 6.5% on 18-in fish to 15.5% on northern pike 22 inches and larger. Across the same length range, the release rate of northern pike decreased from 57.4% for 18-in northern pike to 28.9% for northern pike 22 inches and larger (Figure 5). Overall, anglers reported reward tags at a higher rate than nonreward tags (22.2% versus 16.0%). The reporting rate of nonreward tags relative to reward tags (λ in Pollock et al. 1991) was 88.5%. Based on all tagged northern pike known to be caught, the reported release rate was 43.6%. The estimated exploitation rate for northern pike was 17.5% based on dividing harvest by the multiple-census abundance estimate, and 10.3% based on dividing harvest by the single-census creel survey abundance estimate (Table 4).

Although the survey did not target smallmouth bass, and not enough were tagged to make valuable estimates, anglers returned 6 of 25 reward tags (4 harvested and 2 released) for an estimated exploitation rate of 16.8% (adjusted for an average tag loss rate of 5% derived from previous surveys). Although even fewer muskellunge were tagged, it is worth noting that anglers returned 2 of 7 tags (1 harvested and 1 released) for an estimated exploitation rate of 14.3%.

Recruitment.–For walleye and northern pike in Peavy Pond, variability in year-class strength is relatively low. The R^2 value from the catch curve regression for walleye was 0.91 (Figure 3); thus, annual mortality explains the majority of the variation in the abundance of individual year classes. I did not find any relationships between climatological or water elevation variables and the residuals from the catch curve regression for walleyes in Peavy Pond, but physicochemical data specific to the reservoir are lacking. Water elevation data was only available back to 1993 so comparisons to residuals were limited to available years. For northern pike, the R^2 was 0.98, and there were no significant relationships between tested variables and year-class strength.

Movement.–Based on recaptures during the spring survey, there was movement of walleyes, and to a lesser extent northern pike, throughout Peavy Pond and its main tributaries (Tables 10 and 11). Generally, walleyes were recaptured in the same location in which they were tagged, or downstream of that location. It appeared that walleyes had migrated into the tributaries prior to the survey effort since recaptures during the spring survey never or rarely occurred upstream of initial capture locations. All of the recaptures from walleyes tagged in Peavy Pond came from Peavy Pond; thus there is potentially a segment of the population that spawned in the reservoir. Otherwise, I would have expected some portion of those walleyes tagged in Peavy Pond to have been recaptured in one of the tributaries. Northern pike were largely tagged and recaptured in Peavy Pond, though a few fish moved upstream after being tagged. Fish movement throughout the reservoir was also noted during the mark and recapture population estimates conducted in the spring of 1997 (Mead and Hunt, Inc. 1997).

In addition to movement during the spring survey, there was movement of walleyes, and to a lesser extent northern pike, detected from angler tag returns throughout the year (Tables 12 and 13). While there was movement of fish in both upstream and downstream directions, the majority of walleyes were recaptured by anglers downstream of where they were tagged. In fact, the majority (76%) of all walleye tag returns came from Peavy Pond, even though the majority of walleyes (61%) were tagged in the tributaries. For northern pike, the majority of fish were recaptured by anglers in Peavy Pond, though about 9% of the northern pike tagged in Peavy Pond were recaptured in upstream locations (Table 13). The longest movement detected (approximately 8 miles) was made by a 26.7-inch northern pike that was caught by an angler during September in Lake Mary, which is connected to Peavy Pond via Davison Creek.

Angler Survey

Open-water.–The clerk interviewed 1,778 boating anglers during the open-water period on Peavy Pond. Most interviews (90%) were roving (incomplete-fishing trip). Anglers fished an estimated 22,527 hours and made 4,770 trips (Table 14). The total harvest of 5,972 fish consisted of nine different species. Harvest was dominated by panfish species, which comprised 78% of total catch. Yellow perch were most numerous, with an estimated harvest of 3,501 fish. Anglers harvested 670 walleyes and reported releasing 2,023 walleyes (75% of total walleye catch). Anglers harvested 402 northern pike, and reported releasing 2,736 (87% of total catch). Size composition of the released fish was not evaluated. Both white suckers and muskellunge were caught and released, though no harvest was detected.

Ice-cover.–The clerk interviewed 347 anglers during the ice-cover portion of the angler survey. Most (90%) interviews were roving type (incomplete trip). Anglers fished 3,920 hours and made 853 trips (Table 15). A total of 327 fish were harvested- 131 yellow perch, 120 walleyes, and 76 northern pike. Anglers released 279 northern pike (79% of total northern pike catch), 73 walleyes (38% of total catch), and 22 yellow perch (14% of total catch).

Annual totals.–In the annual period May 8 through October 31, 2004 and December 16, 2004 through February 28, 2005, anglers fished 26,447 hours and made 5,623 trips to Peavy Pond (Tables 14 and 15). Of the total annual fishing effort, 85% occurred in the open-water period and 15% occurred during ice-cover period. The average number of angler hours per day was 127 during the open-water period and 52 during the ice-cover period. Angler effort peaked in July, though it was similar throughout the summer (May through September). Angler effort dropped considerably in October, and remained low through the winter. The total annual harvest was 6,299 fish, of which 95% were taken in the open-water period. Harvest was predominantly panfish, which comprised 76% by number. The estimated total annual harvest of yellow perch was 3,632, making up 58% of the total harvest. The estimated total annual harvest of walleyes and northern pike were 790 and 478, making up 12.5% and 7.6% of the total harvest, respectively. Harvest rates were similar for walleye and northern pike between the open-water and ice-cover periods, though the harvest rate for yellow perch was almost five times higher during the open-water period. There was no creel survey from November through mid-December, because it was thought that relatively little fishing occurred during that time of year, and ice conditions were unsafe. In fact, no walleye or northern pike tag return were reported as being caught during this nonsurveyed period (Table 9). Thus, the estimated total annual walleye and northern pike harvest should accurately reflect the harvest that occurred. April and the first week of May were not surveyed because walleye and northern pike seasons are closed.

Yellow perch were the predominant species caught (harvested + released) at 4,961, with a resulting catch per hour of 0.19. The total catch of walleyes was 2,886, with a catch rate of 0.11 per hour. Walleye catch rates increased from a low of 0.04/h in May to a peak of 0.20/h in September, corresponding with the highest total catch of walleyes. Anglers released 73% of all walleyes caught. Estimated total annual catch of northern pike was 3,493, with a resulting catch rate of 0.13/h. Anglers released 86% of all northern pike caught. It should be noted that catch rates are calculated with general effort, not targeted effort, and are therefore not necessarily indicative of the rate that an angler targeting one species may have experienced. Although no differentiation was made between sublegal and legal released fish, I assume that a large proportion of the released walleye were sublegal. Ten species/hybrids captured during spring netting operations were not detected in the angler catch – black bullhead, brook trout, burbot, creek chub, common shiner, golden shiner, lake whitefish, mottled sculpin, tadpole madtom, and tiger muskellunge.

Discussion

Fish Community

Fish community surveys and observations are noted for Peavy Pond dating back to the 1943, shortly after the reservoir was filled, though most surveys are not suitable for comparison with our 2004 survey since they were completed in different seasons. The original fish community was described by Hazzard (1943) as being comprised of crappie, yellow perch, bullheads, which were directly observed, and likely containing northern pike, walleye, and bass, which were assumed to drift from the river above the reservoir. A survey in June of 1972 using fyke and gill nets collected 113 rock bass, 35 northern pike, 24 yellow perch, 13 white suckers, 9 walleyes, and 1 black crappie. Peavy Pond was surveyed again in July of 1976 using an AC electrofishing boat, and though walleye (N = 90) were the only species collected, good populations of rock bass, yellow perch, and smallmouth bass were noted. In 1984, a summer netting survey collected 1,078 fish comprised of eight species. These eight species were also in the top ten most common species collected in our 2004 survey; though we collected 21 species. Notably absent from the 1984 survey were tadpole madtoms, which comprised 8% of the total catch in 2004. From 1987 through 2004, nine fall electrofishing surveys have been completed in Peavy Pond to index walleye year-class strength, which are discussed in the Recruitment section. There are few historic surveys to make valid comparisons to the 2004 data, but given that fish stocking has not occurred in the reservoir, I would assume that the species composition today is very similar to what it was in the 1940's. The notable exceptions are muskellunge and tadpole madtoms. Muskellunge migrated into Peavy Pond from headwater lakes of the Paint River basin, in which they were stocked. The absence of tadpole madtoms from previous surveys is interesting, but unresolved. Bailey et al. (2004) collected tadpole madtoms in the Paint River near highway M-69 in 1996 so it is likely that they were also in Peavy Pond at that time. Perhaps populations already existed in the Paint and Michigamme river systems and only reached high enough abundance in the reservoir recently to be detected. An alternative hypothesis is that they were introduced, since they are considered by some anglers to be good bait for walleye and bass (Whiteside and Burr 1986, Sternberg 2008). This seems unlikely since they are not available in area bait shops and local anglers are not known to use them. Given the timing of the 2004 survey of Peavy Pond, the catch was dominated by spring spawners such as walleye, northern pike, and white sucker. Additionally, because of the mesh-size bias, smaller fish were not represented in our sample in proportion to their true abundance in the lake. This includes juveniles of all species as well as entire populations of smaller fishes known to exist in Peavy Pond (various species of minnows). For example, two species of fish (logperch and Johnny darter) have been collected or observed in Peavy Pond in other surveys but were not collected in the spring survey of 2004 (see Appendix).

The overall fish community in Peavy Pond was similar to that of Michigamme Reservoir, another impoundment of the Michigamme River, though it differed from that of Bond Falls Flowage, an impoundment of the Middle Branch of the Ontonagon River. Schneider et al. (2000b) cautioned that trap-net and fyke-net collections provide "imperfect snapshots" of fish community composition in lakes. Yet, with proper consideration of gear biases and sampling time frames, these data can provide indices of species composition and useful insight into fish community dynamics. As part of the Large Lakes Program, the DNR also surveyed Michigamme Reservoir (Hanchin et al. 2005a) and Bond Falls Flowage (Hanchin 2009) using methods and gear similar to those employed on Peavy Pond; thus, it should be reasonable to compare fish community composition among these lakes. Both Michigamme Reservoir (Hanchin et al. 2005a) and Bond Falls Flowage (Hanchin 2009) were surveyed in a manner similar to Peavy Pond, with electrofishing as the primary method for collecting walleyes. The percentage of piscivores in Peavy Pond (46) was identical to Michigamme Reservoir (46), but was much less than Bond Falls Flowage (88). The major difference among the reservoirs was the high relative abundance of pelagic planktivores-insectivores in Peavy Pond, which was due to the large number of yellow perch collected in nets. This may, in part, be due to the higher abundance of aquatic vegetation in Peavy Pond, which yellow perch use as a spawning substrate.

Walleye and Northern Pike

Size structure and sex ratio.–The size structure of walleyes in this survey (53% legal size) was below the median (70%) and mean (70%) of legal-size walleyes in spring surveys for 19 populations surveyed under the Large Lakes Program. The previous surveys on Peavy Pond are not suitable for comparisons of size structure since they were either: conducted in different seasons, conducted using different gears, or had inadequate sample sizes. Based on the length-frequency observed in 2004, walleyes in Peavy Pond are unlikely to attain lengths greater than 20 inches, though a relatively small portion (1%) of the adult population ranged from 21 to 29 inches. The size structure of northern pike (4% ≥ 24 in) was well below both the median (24%) and mean (28%) of legal-size northern pike in spring surveys for 18 populations surveyed under the Large Lakes program. While large (≥ 36 in) northern pike were present in our survey, they comprised less than 1% of the catch. It is clear from the size structure of northern pike that the statewide 24-in minimum size limit would not be a prudent regulation for Peavy Pond. The primary goal of a minimum size limit is to increase the number of fish below the size limit, and there are already numerous northern pike less than 24 inches. In that respect, the regulation (no size limit) in place is better suited for the population. However, given that there is the potential to produce large northern pike, an alternative regulation such as a protected slot limit could allow for multiple objectives (high harvest of small fish and protection of larger fish) to be achieved (Pierce and Tomcko 1997, Paukert et al. 2001).

Abundance.–I consider the single-census estimates of abundance as more accurate than the multiple-census ones for Peavy Pond. The multiple-census estimates for walleyes were lower than the single-census estimates for both legal-size fish and adult fish (Table 4), which is consistent with results from other large lakes (Clark et al. 2004, Hanchin et al 2005a, b, c, Hanchin and Kramer 2007). However, the difference for adult walleyes was smaller than the difference for legal-size walleyes; the multiple-census estimate was only 742 fish lower (11%). The nearby Cisco Lake Chain (Hanchin et al. 2008) and Bond Falls Flowage (Hanchin 2009) had even smaller differences between the multiple- and single-census estimates of adult walleye abundance, which were 1% and 3% lower, respectively. The multiple-census estimate was also much lower (36%) than the previous estimate for Peavy Pond (Mead and Hunt, Inc. 1997). Multiple-census estimates made during the onshore spawning migration of species such as walleyes and northern pike are likely biased low due to size selectivity and unequal vulnerability of fish to near-shore netting (Pierce 1997). In the Large Lakes Program, multiple-census estimates have been consistently lower than single-census estimates. Multiple-census estimates during the spawning migration have the potential problem of incomplete mixing, which is not a problem with the single-census method since it allows sufficient time for marked fish to fully mix with unmarked fish. In comparing surveys conducted similarly to ours, Pierce (1997) concluded that recapturing fish at a later time with a second gear type resulted in estimates that were more valid. Thus, based on the observations of Large Lake Program surveys, surveys in nearby states (Borkholder and Edwards 2001), and the more rigorous evaluation by Pierce (1997), the single-census method is the preferred method for estimating the abundance of spawning walleyes. The single-census estimates of walleye abundance were comparable to the a priori Michigan and Wisconsin model estimates. The single-census estimate for legal-size walleyes was about 19% higher than the Michigan model, and the single-census estimate for adult walleyes was about 13% lower than the Wisconsin model.

The population density of walleyes in Peavy Pond was about average compared to other walleye lakes in Michigan. The single-census estimate for 15-in-and-larger walleyes in Peavy Pond converts to a density of 1.5 fish per acre. Density of legal-size walleyes estimated recently for twenty large lakes in Michigan has averaged 2.0 fish per acre (range = 0.4 to 4.6 fish per acre), though the median (1.6 fish per acre) is a better measure of central tendency for these data (Figure 6). Density in nearby Michigamme Reservoir was also 1.5 fish per acre (Hanchin et al. 2005a). Population density of adult walleyes from the single-census estimate was 2.4 fish per acre, which is slightly lower than the 1997 estimate (3.3/acre) for Peavy Pond, but similar to the 2001 estimate for Michigamme Reservoir (2.6/acre). While the disparity from the 1997 estimate may indicate a decrease in the walleye population, they also used rather different methods, which make comparison difficult. Adult walleye abundance has averaged 3.2 fish per acre (median = 2.4) in twenty large lakes surveyed thus far as part of the Large Lakes program (Figure 7). Nate et al. (2000) reported an average density of 2.2 adult walleyes per acre for 131 northern Wisconsin lakes having natural reproduction.

The population density of northern pike in Peavy Pond was similar to both the past estimate and other estimates from nearby lakes. The population density of adult northern pike in Peavy Pond in 1997 was 2.1 fish per acre compared to the current estimate of 2.3 fish per acre. The nearby Cisco Lake Chain and Bond Falls Flowage had similar densities of 2.9 and 2.6 fish per acre, respectively. However, the estimate for Peavy Pond is above the average (0.9) and median (0.5) estimated recently for eighteen large lakes in Michigan (range 0.02 to 2.9 fish per acre). This discrepancy with the statewide average is due to the fact that many of the lakes surveyed as part of the Large Lakes Program were large (>5,000) lakes with relatively little northern pike spawning habitat. Craig (1996) gave a table of abundance estimates (converted to density) for northern pike from various investigators across North America and Europe, including one from Michigan (Beyerle 1971). The sizes and ages of fish included in these estimates vary, but considering only estimates done for age 1 and older fish, the range in density was 1 to 29 fish per acre. Also, Pierce et al. (1995) estimated abundance and density of northern pike in seven small (<740 acres) Minnesota lakes. Their estimates of density ranged from 4.5 to 22.3 fish per acre for fish age 2 and older. Our estimates of numbers of adult northern pike in Peavy Pond are essentially for fish age 3 and older, so they should be lower. Additionally, the lower density observed in Peavy Pond may be due to the larger size of the lake, relative to the small Minnesota lakes that Pierce et al. (1995) surveyed. Although there was only one other abundance estimate for northern pike greater than or equal to 18 in with which to compare, the density in Peavy Pond (1.2 fish per acre) was slightly lower than that for the nearby Cisco Lake Chain (Hanchin et al. 2008) which had 1.9 fish per acre.

Growth.–Mean lengths-at-age for walleyes from our survey of Peavy Pond were well below the old statewide average (Schneider et al. 2000a) and new statewide from the Status and Trends Program (Wehrly et al. In press), but were similar to those from surveys of other waters in the western Upper Peninsula (Table 6). In fact, all five of these populations had mean lengths-at-age that were at least 2.5 in below the statewide average. Schneider et al. (2000a) suggested that growth indices in the range of ±1.0 in were satisfactory for game fish, so accordingly recent walleye growth in Peavy Pond is not satisfactory. However, it is obvious that walleye populations in the western Upper Peninsula do not grow as fast as those in other parts of Michigan. Additionally, statewide averages were calculated using scales, making comparisons to spine-aged fish inappropriate (Clark et al. 2004). Since managers today are aging walleyes almost entirely with dorsal spines, it is clear that new average mean lengths-at-age are needed. Given the potential regional (at least for the western Upper Peninsula) growth differences around the state, when new averages are calculated for walleyes, regional averages should be considered, rather than statewide averages alone.

The asymptotic length ($L\infty$) provides some insight into the growth potential of the average fish in a population. While some large (>25 in) walleyes were collected in Peavy Pond, the relatively low asymptotic length (21 in) suggests that most walleyes will usually never reach large size. For comparison, the average $L\infty$ for walleyes in other Large Lakes in Michigan (N = 19) is 24 in. The lower growth potential in Peavy Pond is typical of walleye populations in the western Upper Peninsula which tend to have above-average density yet below-average lake productivity. Additionally, the averages from the Large Lakes Program are highly influenced by several of the lakes surveyed that have a connection to the Great Lakes, and abundant forage species because of that connectivity.

Similar to walleyes, mean lengths-at-age for northern pike from our survey of Peavy Pond were below the statewide average, but were similar to those from surveys of other waters in the western Upper Peninsula (Table 6). However, mean growth indices for northern pike in these five populations varied more than walleyes, ranging from -0.6 to -4.6. As with walleyes, statewide averages for northern pike were based entirely on scale aging, which probably overestimated mean lengths for older ages. The asymptotic length ($L\infty$) value (44 in) for northern pike suggests that there is adequate growth potential in Peavy Pond to produce large northern pike. Obviously, this theoretical value is based on the mathematical fit of data to a model, and is not necessarily what can be expected from the population. For example, crews measured over 2,000 northern pike and none exceeded 40 in. The average and median $L\infty$ for northern pike in other Large Lakes in Michigan (N = 18) is 37 in.

Mortality.–Total mortality of walleyes in Peavy Pond was about average and was not indicative of excessive fishing mortality. The average (41%) of eighteen Large Lakes surveyed, which have ranged from 24% to 57%, was only slightly lower than that for Peavy Pond (44%). In nearby Michigamme Reservoir (Hanchin et al. 2005a), the annual mortality rate for all walleyes in 2001 (37%) was slightly lower than in Peavy Pond and was considered relatively low. Across North America total annual mortality estimates for walleyes ranged from 31% in Escanaba Lake, Wisconsin to 70% in Red Lakes, Minnesota (Schneider 1978). The estimate of total annual mortality for walleyes in Peavy Pond was about twice the estimate of annual exploitation. The best estimate of exploitation came from tag returns, which is considered to be a minimum because no adjustment was made for tagging mortality or nonreporting. If these problems occurred to any degree, the tag return estimate would have underestimated exploitation (Miranda et al. 2002); thus, it is safe to say that the exploitation rate on walleyes is approximately 20% in Peavy Pond. Given the total mortality estimate (44%), natural and fishing mortality appear to contribute about equally on walleyes in Peavy Pond. Compared to exploitation rates for walleyes from other lakes in Michigan, the estimate for Peavy Pond is higher than the average (15%) exploitation rate for walleyes from Large Lake surveys (N = 19), which ranged from 4% to 35%. Similar to our estimate, Serns and Kempinger (1981) reported average exploitation rates of 24.6% and 27.3% for male and female walleyes respectively in Escanaba Lake, Wisconsin during 1958-1979. In general, the observed range of walleye exploitation across its distribution is large. For example, Schneider (1978) gave a range of 5% to 50% for lakes in Midwestern North America, and Carlander (1997) gave a range of 5% to 59% for a sample of lakes throughout North America. Additionally, exploitation can vary over time for a single waterbody; in western Lake Erie, estimates ranged from 7.5% to 38.8% from 1989 through 1998 (Thomas and Haas 2000). Aside from estimates of mortality and exploitation, the fifteen year classes of walleyes represented in Peavy Pond is about average for the Large Lakes Program, and exceeds Schneider's (Schneider et al. 2007) suggestion that healthy walleye populations have ten or more age groups.

Total mortality of northern pike in Peavy Pond (56%) was slightly above the average (50%) from 19 northern pike populations surveyed as part of the Large Lakes program in Michigan, but was typical for this area of Michigan. It is also higher than Diana's (1983) estimated total annual mortality from two other Michigan lakes, Murray Lake (24.4%) and Lac Vieux Desert (36.2%). Other western Upper Peninsula lakes—Bond Falls Flowage, Cisco Lake Chain, Michgamme Reservoir, and Lake Gogebic—had mortality rates of 48%, 64%, 63%, and 51%, respectively. In Minnesota, Pierce et al. (1995) reported a range of total mortality for northern pike in seven small (< 300 acres) lakes from 36% to 65%. They also summarized total mortality for adult northern pike from a number of lakes across North America; estimates ranged from a low of 19% (Mosindy et al. 1987) to a high of 91% (Kempinger and Carline 1978), with the majority of lakes between 35% and 65%.

The three estimates of northern pike exploitation for Peavy Pond varied slightly (12.5% from tag returns, 17.5% using harvest divided by the multiple-census abundance estimate, and 10.3% using harvest divided by the single-census abundance estimate), but were all within reason. Using the tag return estimate as a minimum, I conservatively estimate the exploitation rate on northern pike as approximately 15% in Peavy Pond. Given the total mortality estimate (56%), natural mortality appears to contribute slightly more than fishing mortality on northern pike in Peavy Pond. However, hooking mortality from released fish is unknown and could be significant given the high percentage (44) of tagged fish that were caught and released. Clark (1983) warned that voluntary release rates higher than 10% change the interpretation of conventional creel survey estimates of catch and fishing mortality. In the case of Peavy Pond, if hooking mortality approached 33%, which is the highest reported in literature for esocids (DuBois et al. 1994, Tomcko 1997), the tag return estimate of exploitation would increase from 12.5% to 16.5% (based on reported releases of tagged fish), but the creel estimate of exploitation would potentially increase from 10.3% to 21.7% (based on all northern pike reported to the creel clerk as being released). This calculation for the total angler kill (harvest plus hooking mortality) divided by abundance was made assuming that released fish had a similar size distribution to what we observed in the nets. Although the assumptions are not necessarily valid, and hooking mortality likely varies with size, if hooking mortality was as high as reported in the literature, it would be a considerable factor in the northern pike fishery in Peavy Pond.

Compared to exploitation rates for northern pike from other lakes in Michigan and elsewhere, our tag return estimate for Peavy Pond (13%) is below average. The mean exploitation rate for northern pike from Large Lake surveys to date is 17% with a range of 3% to 31%. Nearby Cisco Lake Chain, also with no size limit on northern pike, had an estimated exploitation rate of 23% (Hanchin et al. 2008) in 2002. Latta (1972) reported northern pike exploitation in two Michigan lakes, Grebe Lake at 12–23% and Fletcher Pond at 38%. Pierce et al. (1995) reported rates of 8% to 46% for fish over 20 in for seven lakes in Minnesota, and Carlander (1969) gave a range of 14% to 41% for a sample of lakes throughout North America.

Based on the exploitation rate of northern pike by size class it appears that anglers have a preference for harvesting larger northern pike. The exploitation rate on northern pike 22 in or larger was more than double that for 18-in northern pike, while the release rate was half. Thus, if I assume that these size classes of northern pike have similar catchability, it follows that the higher exploitation rate observed on larger northern pike is a result of a higher harvest rate, rather than a higher catch rate. Though I did not stratify the abundance estimates by size class, there are likely many more northern pike from 18 to 21 inches than from 22 inches and above. So, the actual number of small (18–21 in) northern pike harvested could be higher than the number of large (>22 in) northern pike harvested, even with the lower exploitation rate.

Recruitment.–Year-class strength of walleyes is often highly variable, and factors influencing year-class strength have been studied extensively (Chevalier 1973; Busch et al. 1975; Forney 1976; Serns 1982a, 1982b, 1986, 1987; Madenjian et al. 1996; Hansen et al. 1998). Density-dependent factors, such as size of parent stock, and density-independent factors, such as variability of spring water temperatures, have been shown to correlate with success of walleye reproduction. I obtained population data in Peavy Pond for only one year, and so could not rigorously evaluate year-class strength. However, insight about the relative variability of recruitment can be gained by examining the properties of the catch-curve regressions for walleyes and northern pike. For example, Maceina (2003) used catch-curve residuals as a quantitative index of the relative year-class strength of black crappie and white crappie in Alabama reservoirs. He showed that residuals were related to various hydrological variables in the reservoirs. Walleyes in Peavy Pond were represented by 15 year classes (ages 1 through 15) in our samples. Since most of the variation in walleye catch by age class was explained by annual mortality ($R^2 = 0.91$; Figure 3), variability in year-class strength appeared to be low. In other Michigan walleye populations surveyed as part of the Large Lakes program to date (N = 19), the R^2 has ranged from 0.50 to 0.98, with an average of 0.80. Given that walleyes are not stocked in Peavy Pond, it appears that natural reproduction occurs consistently. Accordingly, in nine fall electrofishing surveys to evaluate walleye year-class strength in Peavy Pond from 1987 to 2004 (DNR, unpublished data) no year class failures have been observed.

Similar to walleyes, northern pike recruitment appeared to be rather consistent. Northern pike were represented by ten year classes (ages 1 through 10) in our samples. Almost all of the variation in catch by age class was explained by annual mortality ($R^2 = 0.98$; Figure 4); thus, variability in northern pike year-class strength is low. In other Michigan northern pike populations surveyed as part of the Large Lakes program (N = 17) the R^2 has ranged from 0.67 to 1.00, with an average of 0.89 and median of 0.91.

Movement.–The majority of walleyes in the Peavy Pond system migrate up the tributaries to spawn, which is not surprising given that the population existed in the Michigamme River prior to its impoundment. While our survey did not discover the exact timing of that upstream migration, few walleyes were recaptured during our spring survey in locations upstream of their initial capture locations. Thus, the majority of the spawning run likely entered the river prior to our electrofishing efforts, which began April 15. Recaptures during the spring survey did indicate quick downstream movement of walleyes however, which likely occurred following spawning. Hanchin et al. (2007) also noted rapid downstream movement of river-migrant walleyes following spawning. Angler tag returns also demonstrated the tendency of walleyes to move downstream following spawning, though some walleyes stayed in the river throughout the year. The latest dates that tag returns were reported from the river were August 26, 2004 from the northern portion of the Michigamme River, and September 24, 2004 from the southern portion of the Michigamme River.

Angler Survey

Summary.–The fishery of Peavy Pond is typical of lakes in the western Upper Peninsula. The angler catch was dominated by yellow perch, northern pike, and walleyes, which comprised 76% of the total. The majority of both walleyes and northern pike caught were released, which is a result of the relatively low size structure for both of these species. While the 15-in minimum size limit for walleyes dictates the release of many small (13 to 14 in) walleyes, there was no minimum size limit for northern pike, suggesting that most anglers are releasing small northern pike voluntarily. The catch rate for walleyes varied throughout the year and peaked in September (0.20 per hour), coinciding with the highest number released, rather than harvested. It appears that the catch of small walleyes peaks in the fall, possibly when immature fish begin to congregate in schools. Hanchin and Kramer (2007) observed the same occurrence in Big Manistique Lake in the Upper Peninsula of Michigan. The open-water period accounted for 95% of the annual catch, and 85% of the annual effort. Considering the number of days sampled in the open-water (177) and winter (75) periods, the angling effort per day (total effort / sample days) was much higher in the open-water period (127 versus 52 angler hours per day). Overall, the fishery of Peavy Pond is not very diverse, especially in the winter when yellow perch, walleyes, and northern pike were the only species caught. Muskellunge obviously provide some angling opportunity in the Peavy Pond system throughout the year, though very few were caught.

Historical comparisons.–A general creel survey, designed only to measure the success of anglers who were actually interviewed, was conducted from approximately 1951 to 1961. During this period, yellow perch comprised 31% of the total harvest, followed by walleyes (29%), black crappies (24%), and northern pike (8%). The remaining 7% of the catch was made up of bluegills, rock bass, smallmouth bass, largemouth bass, and suckers. Although it is difficult to draw conclusions from surveys based on such different methods, the species composition of the angler harvest in 2004 is similar, with the exception of black crappies, which comprised 24% of the harvest in the 1950's, but only 5% of the harvest in 2004. Additionally, muskellunge were not caught, or at least not reported, in the 1950's, but were reported as being released in 2004.

Comparison to other large lakes.–In addition to the historic creel survey data for Peavy Pond, comparisons with creel surveys from other large lakes can be useful. Thus far in the Large Lakes Program, creel surveys have been conducted on 16 lakes which can be used for comparisons. An estimated 26,447 angler hours occurred on Peavy Pond during the creel survey, which corresponds to 9.5 hours per acre. This is below the mean value for other lakes surveyed under the Large Lakes Program, but is near the median value (Table 16). The harvest for Peavy Pond was 2.3 fish per acre, which is also below the mean, but near the median value for other large lakes. Michigan lakes with a high harvest per acre generally have popular bluegill/sunfish fisheries that bolster the total harvest.

For walleyes, the estimated annual harvest from Peavy Pond was 0.28 fish per acre, which is low relative to the average (0.51 per acre) and median (0.45 per acre) for nineteen lakes surveyed as part of the Large Lakes Program. The lowest value observed has been 0.06 per acre in Grand (Hanchin 2011) and Long (Hanchin and Cwalinski 2011) lakes, while the highest value (1.61 per acre) occurred in South Manistique Lake (Hanchin and Kramer 2008a). The average harvest of six other large Michigan Lakes (> 1,000 acres) reported by Lockwood (2000a) was 0.63 walleyes per acre, ranging from 0.09 for Brevoort Lake to 1.68 for Chicagon Lake. These Michigan lakes were subject to similar gears and fishing regulations, including a 15-in-minimum size limit. The low harvest per acre of walleyes in Peavy Pond is largely due to the small size structure of walleyes, since angler effort and density were only slightly below average.

For northern pike, the estimated annual harvest was 0.17 fish per acre, which was above average compared to other waters in Michigan. The average harvest in sixteen other lakes sampled in the Large Lakes Program was 0.08 northern pike per acre, ranging from 0.003 in North Manistique Lake (Hanchin and Kramer 2008b) to 0.464 in Houghton Lake (Clark et al. 2004). However, these lakes were all subject to a 24-in minimum size limit, so the higher harvest per acre in Peavy Pond is expected given there was no size limit on northern pike. The average harvest of seven other large Michigan lakes (> 1,000 acres) reported by Lockwood (2000a) was 0.151 northern pike per acre, ranging from 0.002 per acre in Bond Falls Flowage to 0.654 per acre in Fletcher Pond. The lakes reported by Lockwood (2000a) were all subject to similar gears and fishing regulations, including a 24-in minimum size limit. When the harvest per acre of northern pike in Peavy Pond is compared to that from the nearby Cisco Lake Chain (0.64 per acre, Hanchin et al. 2008), a lake without a minimum size limit, it appears low. Elsewhere, Pierce et al. (1995) estimated harvests from 0.7 to 3.6 per acre in seven smaller Minnesota lakes. These lakes ranged from 136 to 628 acres in size and had no minimum size limit for northern pike.

Yellow perch are the major panfish species in Peavy Pond, with an estimated annual harvest of 1.3 per acre. In comparison, harvest per acre of yellow perch was 3.4 for Burt Lake (Hanchin et al. 2005b), 2.5 in Houghton Lake (Clark et al. 2004), 1.8 in Crooked and Pickerel lakes (Hanchin et al 2005c), 1.6 in Grand Lake (Hanchin 2011), and 0.9 in Long Lake (Hanchin and Cwalinski 2011). The associated harvest rate for yellow perch in Peavy Pond was 0.14 per hour, compared to 0.44 per hour for Burt Lake, 0.27 per hour for Grand Lake (Hanchin 2011), 0.14 per hour for Long Lake (Hanchin and Cwalinski 2011), 0.11 per hour for Crooked and Pickerel lakes (Hanchin et al. 2005b), and 0.10 per hour for Houghton Lake (Clark et al. 2004). Thus, the fishery compares fairly well with other large lakes that have well-known yellow perch fisheries.

Summary

The walleye population in Peavy Pond has consistent recruitment, and growth is about average relative to other lakes in the western Upper Peninsula. Mortality was within acceptable limits, with approximately equal contributions from fishing and natural sources. Although the overall size structure of walleyes is considered low, there are large walleyes (up to 29 inches) in the population. In 2004, there were an estimated 1.5 legal-size walleyes per acre and anglers harvested 0.3 per acre at a rate of 0.03 per hour fished. While walleye density is near the central tendency of other large lakes surveyed recently in Michigan, the harvest values are slightly below average. In contrast, the catch rate for walleyes is equal to the mean and greater than the median from other large lakes since there are many fish of sublegal size. Although the creel survey only occurred on the impoundment, anglers obviously target walleyes in both the impoundment and the tributaries, with 24% of tag returns coming from the Michigamme and Paint rivers.

The estimate of adult walleye abundance from the Michigan regression equation was 28% lower than the empirical estimate, while the prediction from the Wisconsin regression equation was 15% higher. It would be reasonable to apply either regression equation for an approximate estimate of adult walleye abundance in Peavy Pond, though the Wisconsin equation and any harvest limits for Peavy Pond based upon it should be regarded as biased high. The most appropriate value for setting a conservative harvest limit would be the lower 95% confidence limit for our estimate of adult walleye abundance, or 5,074 adult walleyes. Additionally, given the relatively tight confidence interval for this estimate, a harvest limit based on the lower limit would not differ that much from one based on the point estimate.

Northern pike are just as abundant as walleyes in Peavy Pond. The density of the adult population is higher than in most large Michigan lakes, though the size structure is rather low. Given the high density, the population has slower than average growth. Total mortality is above average, though within acceptable limits. Anglers harvested 0.17 northern pike per acre at a rate of 0.02 per hour. Both of these figures are high compared to other large lakes in Michigan, but that is expected given the absence of a minimum size limit that restricts harvest.

In general, the hours fished per acre and total number of fish harvested per acre were similar to other large lakes in Michigan. Angling effort was concentrated during the open-water period, during which angler hours per day were almost 2.5 times higher.

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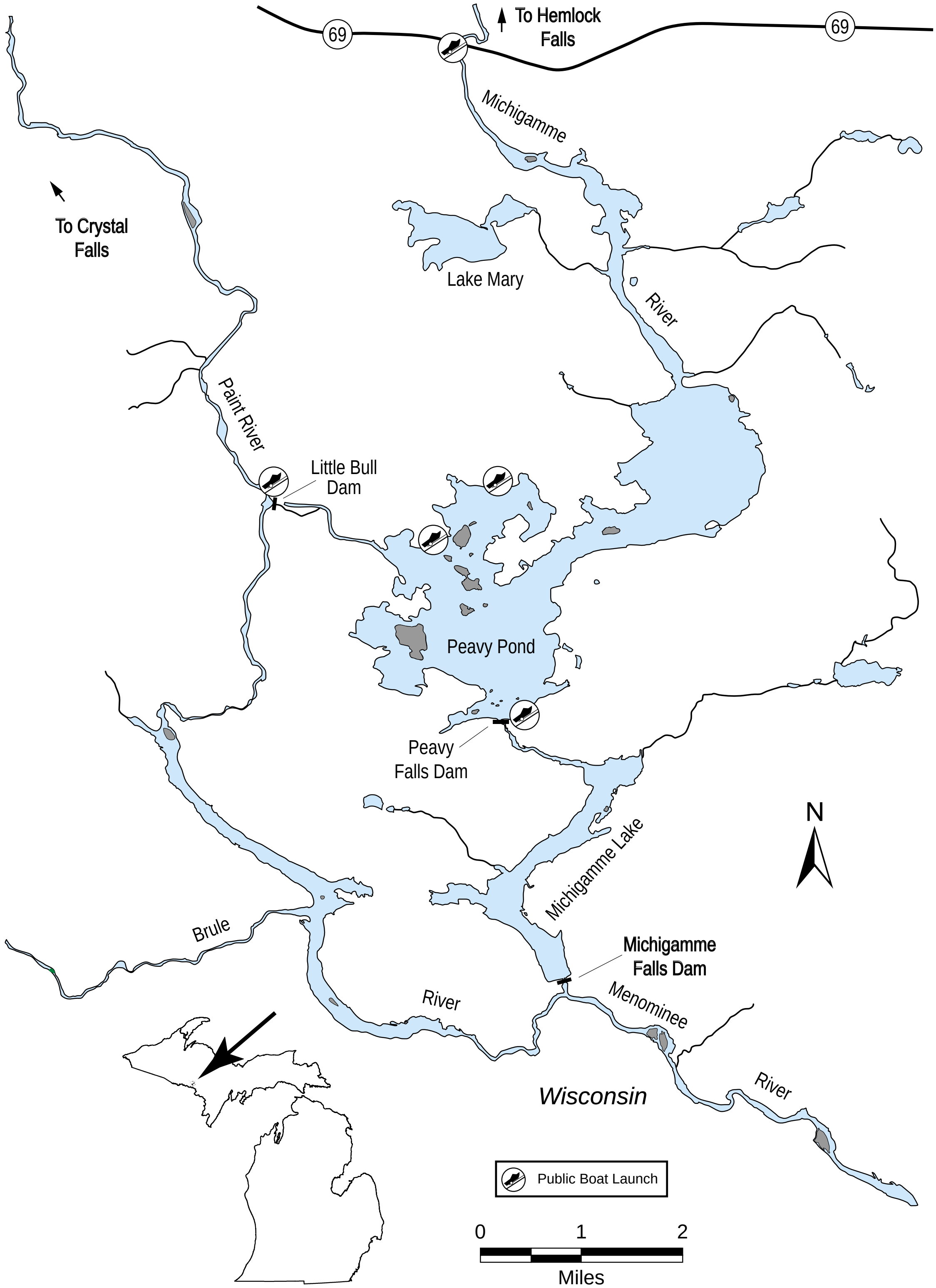

Figure 1.–Map of Peavy Pond, Iron County, Michigan.

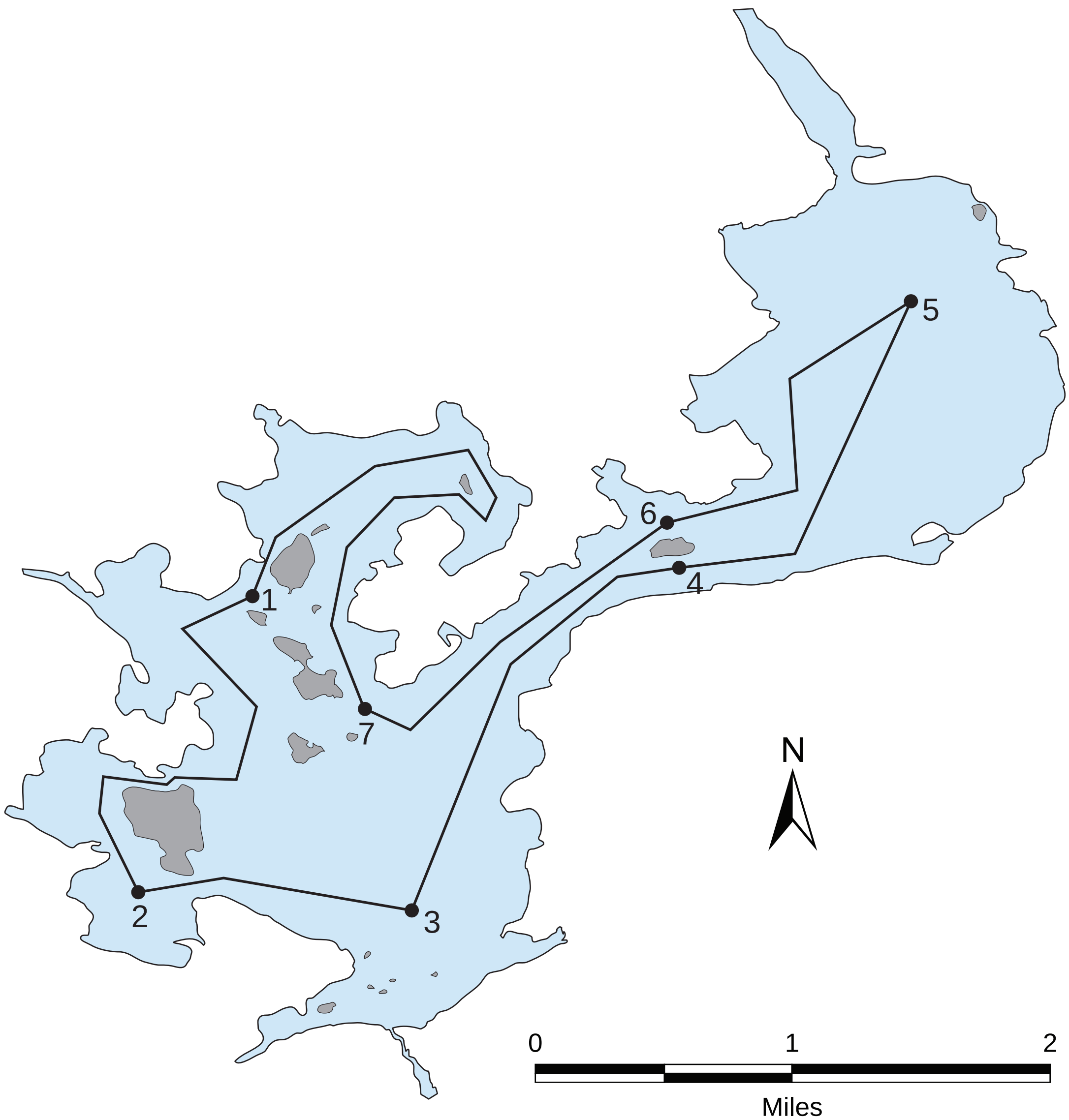

Figure 2.–Counting path and associated count path way points for the Peavy Pond, summer 2004 and winter 2005 creel surveys.

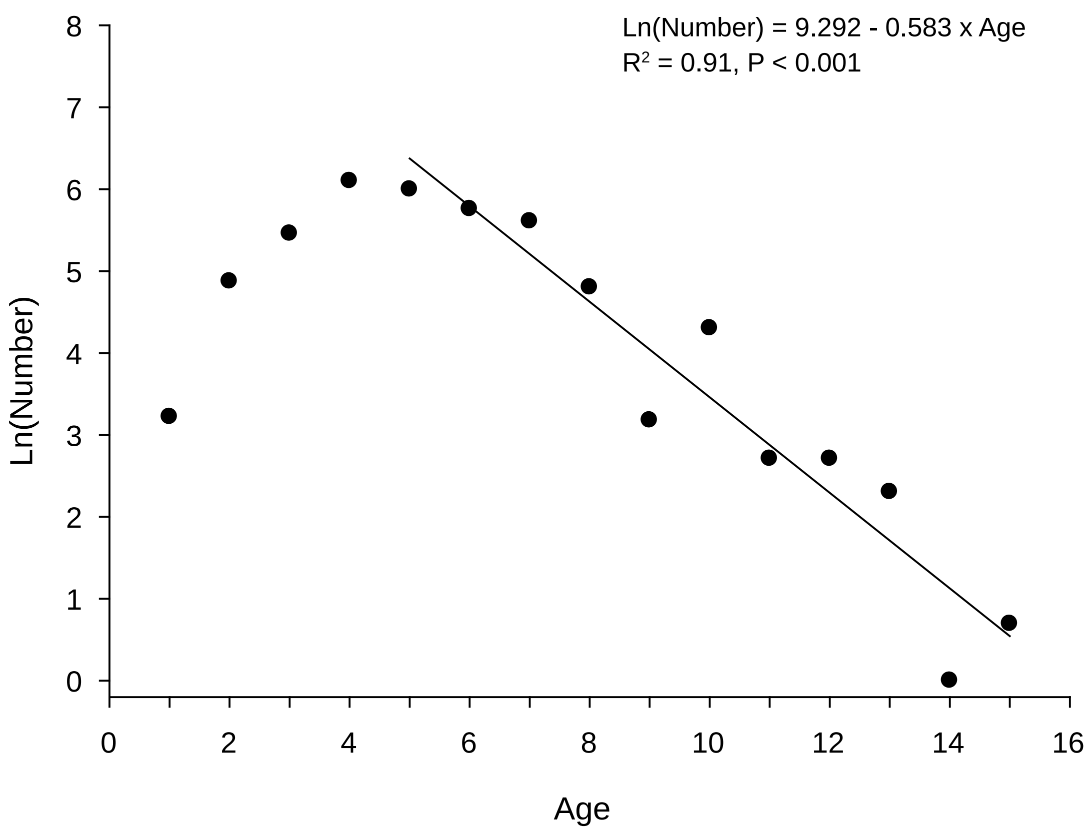

Figure 3.–Plot of observed ln(number) versus age for legal-size walleyes and in Peavy Pond. Line is a plot of the regression equation given.

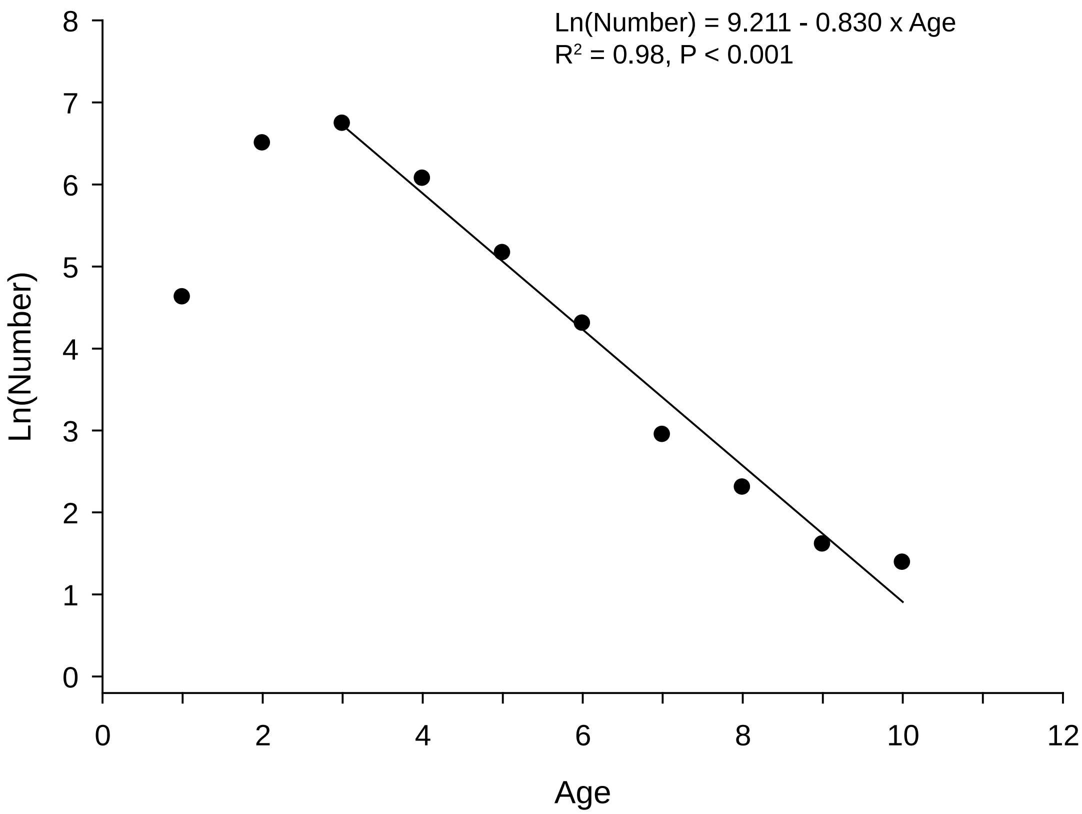

Figure 4.–Plot of observed ln(number) versus age for adult northern pike in Peavy Pond. Line is a plot of regression equation given.

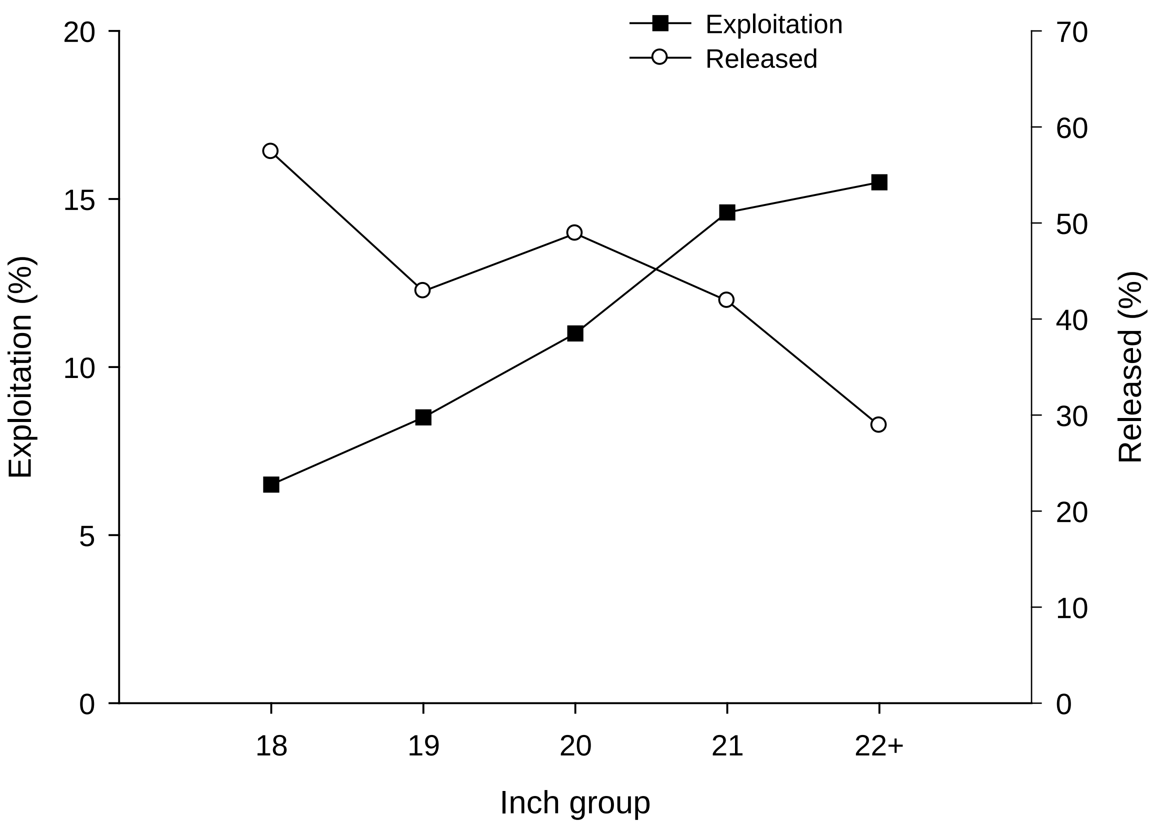

Figure 5.– Plots of exploitation (percentage of reward and non-reward tags harvested) and release rate (percentage of tag returns reported as being released) for northern pike by inch group in Peavy Pond during the year following tagging.

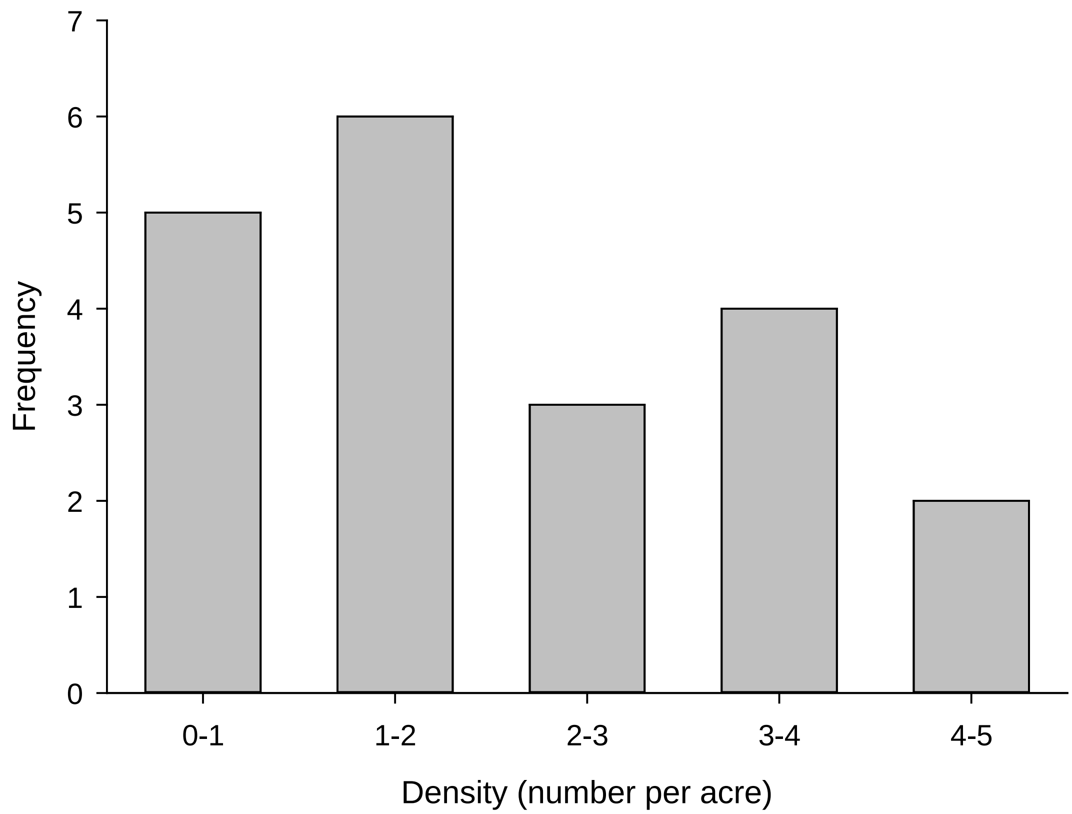

Figure 6.–Distribution of density estimates for legal-size (≥ 15 in) walleyes in twenty Michigan lakes sampled under the Large Lake Program.

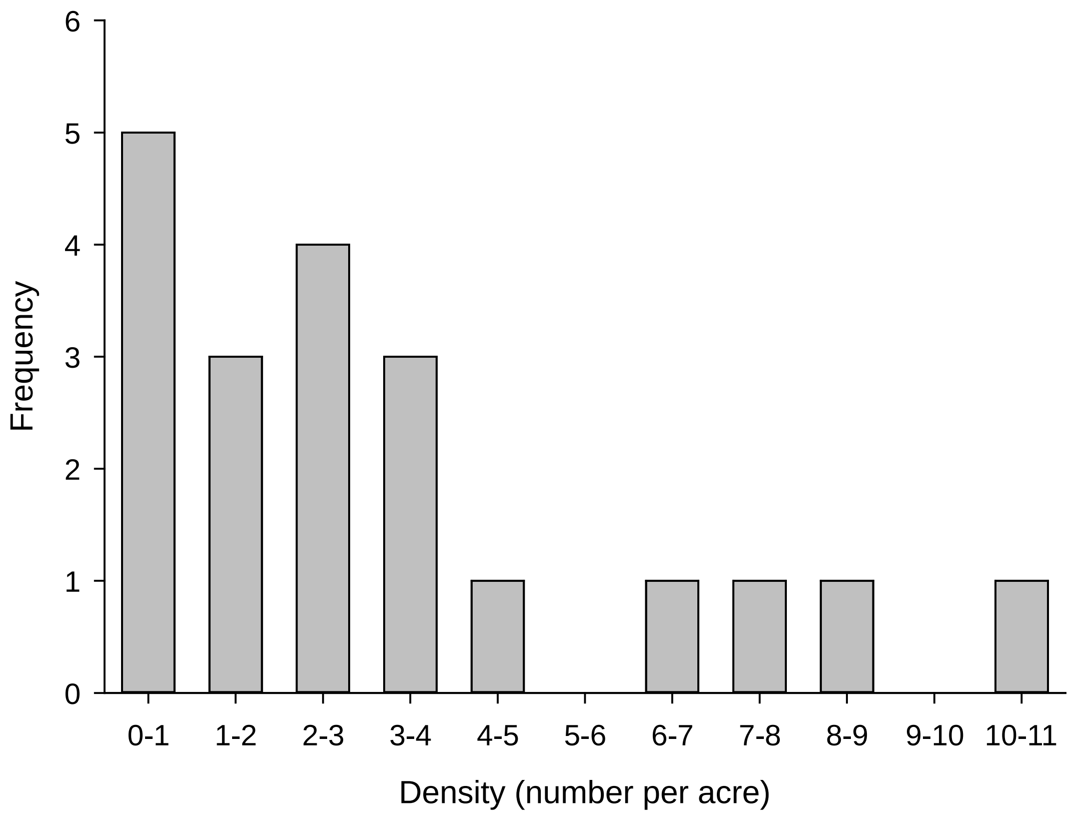

Figure 7.– Distribution of density estimates for adult walleyes in twenty Michigan lakes samples under the Large Lake Program.

Table 1.–Survey periods, sampling shifts, and expansion value "F" (number of fishing hours within a sample day) for the Peavy Pond angler survey, spring 2004 through winter 2005.

Survey period	Sample shift (h)		F
May 8–May 31	0600–1430	1330–2200	17
June	0600–1430	1330–2200	17
July	0600–1430	1300–2130	17
August	0630–1500	1230–2100	16
September	0630–1500	1200–2030	15
October	0700–1530	1130–2000	14
December 16–31	0700–1530	0930–1800	13
January	0700–1530	1100–1930	13
February	0700–1530	1100–1930	13

Table 2.–Fish collected from Peavy Pond and its tributaries using a total sampling effort of 399 fyke-net lifts and 54 electrofishing runs from April 15–May 5, 2004.

Species	Total catch[a]	Percent by number	Mean fyke-net CPUE[a,b]	Length range (in)	Average length (in)[c]	Number measured[c]
Yellow perch	4,670	36.4	10.2	2.6–14.3	6.2	837
Northern pike	3,310	25.8	6.3	5.6–38.5	18.1	2,336
Walleyes	2,509	19.5	0.9	4.7–29.4	14.9	2,095
Tadpole madtom	963	7.5	2.3	1.5–4.8	3.2	433
Rock bass	587	4.6	1.2	1.8–10.6	6.6	560
Bluegill	296	2.3	0.7	3.5–10.3	7.4	296
White sucker	165	1.3	0.4	3.4–24.6	17.0	165
Black crappie	100	0.8	0.2	2.5–13.6	11.1	100
Pumpkinseed	68	0.5	0.2	2.9–8.1	5.2	68
Smallmouth bass	60	0.5	<0.1	3.0–20.4	15.4	58
Muskellunge	31	0.2	<0.1	9.5–48.1	31.9	31
Burbot	27	0.2	<0.1	7.4–24.6	19.6	27
Golden shiner	18	0.1	<0.1	3.9–5.9	4.5	18
Common shiner	18	0.1	<0.1	3.2–6.5	4.1	18
Creek chub	4	<0.1	<0.1	4.1–7.8	6.4	4
Lake whitefish	4	<0.1	0	14.4–18.1	16.6	4
Mottled sculpin	2	<0.1	<0.1	3.0–3.2	3.1	2
Largemouth bass	2	<0.1	<0.1	15.5–18.0	16.8	2
Black bullhead	1	<0.1	<0.1	3.5	3.5	1
Brook trout	1	<0.1	0	14.0	14.0	1
Tiger muskellunge	1	<0.1	<0.1	39.7	39.7	1

[a] Includes recaptures
[b] Number per trap-net or fyke-net night
[c] Does not include recaptures for walleyes, northern pike, or smallmouth bass.

Table 3.–Number of fish per inch group collected from the Peavy Pond system, April 15–May 5, 2004.

	Species																				
Inch group	Yellow perch	Northern pike	Walleyes	Tadpole madtom	Rock bass	Bluegill	White sucker	Black crappie	Pumpkinseed	Smallmouth bass	Muskellunge	Burbot	Golden shiner	Common shiner	Creek chub	Lake whitefish	Mottled sculpin	Largemouth bass	Black bullhead	Brook trout	Tiger muskellunge
1	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	1	—	—	134	11	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—
3	53	—	—	279	37	4	3	—	15	1	—	—	1	9	—	—	2	—	1	—	—
4	210	—	1	19	68	18	2	—	7	—	—	—	15	7	1	—	—	—	—	—	—
5	244	1	1	—	96	15	6	1	28	—	—	—	2	1	—	—	—	—	—	—	—
6	83	1	11	—	77	33	10	5	13	—	—	—	—	1	2	—	—	—	—	—	—
7	86	3	14	—	109	125	3	—	2	—	—	1	—	—	1	—	—	—	—	—	—
8	61	14	42	—	99	86	4	3	2	1	—	—	—	—	—	—	—	—	—	—	—
9	49	25	65	—	52	14	2	7	—	1	1	9	—	—	—	—	—	—	—	—	—
10	22	33	58	—	10	1	1	5	—	1	—	—	—	—	—	—	—	—	—	—	—
11	19	26	72	—	—	—	—	39	—	—	—	—	—	—	—	—	—	—	—	—	—
12	7	44	132	—	—	—	—	34	—	—	—	—	—	—	—	—	—	—	—	—	—
13	1	72	198	—	—	—	4	4	—	3	—	—	—	—	—	—	—	—	—	—	—
14	1	158	389	—	—	—	8	—	—	12	1	2	—	—	—	1	—	—	—	1	—
15	—	214	442	—	—	—	9	—	—	13	—	1	—	—	—	—	—	1	—	—	—
16	—	244	317	—	—	—	4	—	—	15	1	—	—	—	—	1	—	—	—	—	—
17	—	272	151	—	—	—	12	—	—	7	2	2	—	—	—	1	—	—	—	—	—
18	—	326	96	—	—	—	20	—	—	2	1	2	—	—	—	1	—	1	—	—	—
19	—	347	47	—	—	—	13	—	—	1	1	2	—	—	—	—	—	—	—	—	—
20	—	218	32	—	—	—	13	—	—	1	—	4	—	—	—	—	—	—	—	—	—
21	—	129	7	—	—	—	14	—	—	—	—	2	—	—	—	—	—	—	—	—	—
22	—	64	4	—	—	—	31	—	—	—	—	5	—	—	—	—	—	—	—	—	—
23	—	46	3	—	—	—	5	—	—	—	—	2	—	—	—	—	—	—	—	—	—
24	—	22	2	—	—	—	1	—	—	—	—	3	—	—	—	—	—	—	—	—	—
25	—	20	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
26	—	14	4	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—
27	—	7	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
28	—	6	1	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—

Table 3.–Continued.

Inch group	Species																				
	Yellow perch	Northern pike	Walleyes	Tadpole madtom	Rock bass	Bluegill	White sucker	Black crappie	Pumpkinseed	Smallmouth bass	Muskellunge	Burbot	Golden shiner	Common shiner	Creek chub	Lake whitefish	Mottled sculpin	Largemouth bass	Black bullhead	Brook trout	Tiger muskellunge
29	—	3	1	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—
30	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
31	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32	—	2	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
33	—	2	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—
34	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
35	—	2	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
36	—	6	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
37	—	3	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
38	—	4	—	—	—	—	—	—	—	—	4	—	—	—	—	—	—	—	—	—	—
39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
41	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
42	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
43	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
44	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—
45	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
46	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
47	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
48	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Total	837	2,336	2,095	433	560	296	165	100	68	58	31	27	18	18	4	4	2	2	1	1	1

Table 4.–Estimates of abundance, angler exploitation rates, and instantaneous fishing mortality rates for Peavy Pond walleyes and northern pike using the different methods described in text. Asymmetrical 95% confidence intervals for estimates are given in parentheses, where applicable.

Parameter	Walleyes	Northern pike
Number tagged	1,107	1,222
Total tag returns[a]	195	227
Number of legal-size[b] fish		
Multiple-census estimate	2,614	2,054
	(2,284–3,054)	(1,822–2,352)
Single-census estimate	4,082	3,471
	(3,067–5,551)	(2,511–4,431)
Michigan model prediction[c]	3,442	–
	(746–15,887)	
Number of adult[d] fish		
Multiple-census method	6,011	4,740
	(5,000–7,534)	(4,233–5,384)
Single-census estimate	6,753	6,336
	(5,074–9,184)	(4,528–9,135)
Michigan model prediction[e]	4,865	–
	(926–25,545)	
Wisconsin model prediction[f]	7,761	–
	(2,555–23,573)	
Annual exploitation rates		
Based on reward tag returns	18.7%	12.5%
Based on harvest/abundance[g]	24.2%	17.5%
	(17.3–31.2%)	(11.2–23.7%)
Based on harvest/abundance[h]	15.5%	10.3%
	(10.0–21.1%)	(5.8–14.8%)
Total annual mortality rates	44%	56%

[a] Voluntary tag returns plus tags observed by creel clerk that were not returned by anglers.
[b] Walleyes ≥ 15 in, and northern pike ≥ 18 in (minimum size acceptable to anglers).
[c] Michigan model prediction of legal walleye abundance based on lake area, N = 32.
[d] Fish of legal-size and sexually mature fish of sub-legal size on spawning grounds.
[e] Michigan model prediction of adult walleye abundance based on lake area, N = 31
[f] Wisconsin model prediction of adult walleye abundance based on lake area, N = 185.
[g] Multiple-census estimate of legal-size walleye abundance.
[h] Single-census estimate of legal-size walleye abundance.

Table 5.–Weighted mean total lengths (in) and sample sizes by age for walleyes and northern pike collected from the Peavy Pond system, April 15–May 5, 2004. Standard deviation is in parentheses.

Age	Mean length				Number aged	
	Walleyes		Northern pike		Walleyes	Northern pike
1	7.1	(0.5)	10.2	(1.2)	13	75
2	9.3	(0.7)	15.3	(1.5)	68	132
3	12.3	(1.2)	18.4	(1.4)	65	92
4	14.1	(0.8)	19.9	(1.6)	46	65
5	15.2	(1.2)	22.0	(2.2)	36	60
6	16.1	(1.4)	25.0	(4.0)	35	41
7	16.5	(1.3)	27.0	(4.0)	33	15
8	17.3	(1.5)	34.1	(4.4)	19	8
9	19.4	(1.0)	32.7	(4.9)	11	4
10	18.0	(2.9)	34.9	(5.7)	19	4
11	20.6	(3.0)	–		7	
12	20.7	(1.0)	–		9	
13	21.7	(3.4)	–		5	
14	29.4	(–)	–		1	
15	27.9	(–)	–		1	

[a] Mean length for ‘All fish’ includes males, females, and fish of unknown sex.

Table 6.–Mean total lengths (in) of walleyes (males and females combined) from the 2004 survey of Peavy Pond compared to other surveys of comparable waters. Number of walleyes aged in parentheses. State averages were not calculated for older groups since there were not enough survey/lakes that met the minimum sample size for inclusion.

			Lake / Survey year					
	State	State	Peavy Pond	Lake Michigamme	Bond Falls Flowage	Southern Cisco Lake Chain	Michigamme Reservoir	Lake Gogebic
Age	average[a]	average[b]	2004[c]	2006[c]	2003[c]	2002[c]	2001[c]	1999[c]
1	7.1	8.0	7.1 (13)					
2	10.4	12.0	9.3 (68)	7.9 (5)	10.7 (3)	10.7 (5)	8.3 (9)	
3	13.9	14.3	12.3 (65)	11.5 (10)	12.0 (10)	11.6 (52)	12.5 (76)	11.4 (1)
4	15.8	16.6	14.1 (46)	14.3 (32)	13.9 (34)	13.3 (48)	14.0 (90)	13.0 (1)
5	17.6	18.8	15.2 (36)	15.2 (36)	15.4 (51)	14.3 (68)	14.8 (41)	13.8 (34)
6	19.2	19.7	16.1 (35)	15.7 (13)	16.6 (16)	15.0 (19)	15.5 (91)	16.4 (2)
7	20.6	21.2	16.5 (33)	16.5 (38)	16.7 (9)	16.4 (53)	16.2 (64)	16.7 (1)
8	21.6	21.5	17.3 (19)	16.3 (40)	17.8 (38)	17.6 (48)	16.8 (20)	17.1 (10)
9	22.4	22.1	19.4 (11)	17.6 (39)	18.0 (30)	16.8 (11)	18.7 (15)	17.0 (3)
10	23.1	22.6	18.0 (19)	18.4 (15)	17.3 (11)	20.4 (13)	19.4 (15)	17.8 (7)
11		23.1	20.6 (7)	18.6 (20)	21.3 (6)	23.0 (31)	20.3 (12)	17.3 (2)
12		23.3	20.7 (9)	20.1 (16)	19.9 (3)	21.5 (18)	18.7 (19)	
13		24.1	21.7 (5)	22.9 (10)		24.1 (22)	19.9 (9)	20.1 (3)
14			29.4 (1)	23.7 (11)		23.6 (19)	19.3 (11)	
15			27.9 (1)	21.4 (6)	20.1 (3)	24.6 (5)	20.2 (3)	
16				23.6 (7)	20.2 (2)	28.3 (4)	19.5 (3)	
17				25.1 (2)			20.5 (1)	
18				24.5 (1)				
Mean growth index[d]			-2.6	-3.5	-3.3	-3.2	-3.2	-3.3

[a] Jan–May averages from Schneider et al (2000a), aged using scales.
[b] Average from Wehrly et al. (in press), aged using spines. Most lakes were sampled from during May and June.
[c] Fish collected in the spring and aged using spines.
[d] The mean deviation from the statewide quarterly average. Only age groups where N ≥ 5 were used.

Table 7.–Mean total lengths (in) of northern pike (males and females combined) from the 2004 survey of Peavy Pond compared to other surveys of comparable waters. Number of northern pike aged in parentheses.

		Lake / Survey year				
	State	Peavy Pond	Bond Falls Flowage	Cisco Lake Chain	Michigamme Reservoir	Lac Vieux Desert
Age	average[a]	2004[b]	2003[b]	2002[b]	2001[b]	1998[b]
1	11.7	10.2 (75)	12.2 (11)	11.1 (57)		
2	17.7	15.3 (132)	17.4 (52)	15.8 (167)	16.0 (94)	14.5 (3)
3	20.8	18.4 (92)	20.1 (73)	17.8 (177)	18.8 (118)	16.2 (17)
4	23.4	19.9 (65)	22.3 (79)	19.2 (274)	20.6 (64)	18.8 (10)
5	25.5	22.0 (60)	22.8 (20)	21.6 (111)	21.3 (51)	24.5 (1)
6	27.3	25.0 (41)	23.7 (3)	22.5 (37)	25.3 (35)	19.2 (2)
7	29.3	27.0 (15)	27.3 (5)	25.5 (24)	25.6 (21)	
8	31.2	34.1 (8)	33.6 (6)	21.6 (7)	27.5 (3)	
9		32.7 (4)	37.3 (3)	28.6 (5)	36.3 (4)	
10		34.9 (4)	35.1 (1)			
11					34.0 (1)	
12						
Mean growth index[c]		-1.9	-0.6	-4.0	-2.7	-4.6

[a] Jan–May averages from Schneider et al (2000a), aged using scales.
[b] Fish collected in the spring and aged using fin rays.
[c] The mean deviation from the Statewide quarterly average. Only age groups where N ≥ 5 were used.

Table 8.–Catch at age estimates (apportioned by age-length key) for walleyes and northern pike from the Peavy Pond system, April 15–May 5, 2004.

Age	Year class	Walleyes	Northern pike
1	2003	25	102
2	2002	131	667
3	2001	235	846
4	2000	446	433
5	1999	403	175
6	1998	317	74
7	1997	273	19
8	1996	122	10
9	1995	24	5
10	1994	74	4
11	1993	15	0
12	1992	15	0
13	1991	10	0
14	1990	1	0
15	1989	2	0
Total		2,093	2,335

Table 9.–Voluntary angler tag returns (reward and non-reward, harvested and released combined) from walleyes and northern pike by month for the year following tagging in the Peavy Pond system. Tags observed by creel clerk, but not reported by angler are not included. Percentage of total is in parentheses.

	Species	
Month	Walleyes	Northern pike
4	0 (0)	0 (0)
5	43 (22.1)	77 (34.5)
6	50 (25.6)	76 (34.1)
7	42 (21.5)	44 (19.7)
8	28 (14.4)	14 (6.3)
9	13 (6.7)	11 (4.9)
10	5 (2.6)	1 (0.4)
11	0 (0)	0 (0)
12	2 (1)	0 (0)
1	4 (2.1)	0 (0)
2	8 (4.1)	0 (0)
3	0 (0)	0 (0)
Total	195	223

Table 10.–Movement of walleyes in the Peavy Pond system based on re-captures during the spring survey (April 15 to May 5, 2004). Percent of total recaptured fish is in parentheses.

	Recapture location			
Tagging location	Peavy Pond	N. Michigamme River	S. Michigamme River	Paint River
Peavy Pond	35 (100.0)	0 (0)	0 (0)	0 (0)
N. Michigamme River	6 (2.6)	135 (59.0)	88 (38.4)	0 (0)
S. Michigamme River	2 (8.7)	2 (8.7)	19 (82.6)	0 (0)
Paint River	2 (13.3)	0 (0)	0 (0)	13 (86.7)

Table 11.–Movement of northern pike in the Peavy Pond system based on re-captures during the spring survey (April 15 to May 5, 2004). Percent of total recaptured fish is in parentheses.

	Recapture location			
Tagging location	Peavy Pond	N. Michigamme River	S. Michigamme River	Paint River
Peavy Pond	582 (99.1)	0 (0)	5 (0.9)	0 (0)
N. Michigamme River	1 (100.0)	0 (0)	0 (0)	0 (0)
S. Michigamme River	0 (0)	1 (50.0)	1 (50.0)	0 (0)
Paint River	0 (0)	0 (0)	0 (0)	0 (0)

Table 12.–Movement of walleyes in the Peavy Pond system based on voluntary angler tag returns (reward and non-reward, harvested and released) during the angling season following tagging (May 15, 2004 to February 28, 2005). Percent of total recaptured fish is in parentheses.

	Recapture location			
Tagging location	Peavy Pond	N. Michigamme River	S. Michigamme River	Paint River
Peavy Pond	68 (95.8)	0 (0)	3 (4.2)	0 (0)
N. Michigamme River	48 (60.0)	9 (11.3)	23 (28.8)	0 (0)
S. Michigamme River	28 (77.8)	0 (0)	8 (22.2)	0 (0)
Paint River	4 (50.0)	0 (0)	1 (12.5)	3 (37.5)

Table 13.–Movement of northern pike in the Peavy Pond system based on voluntary angler tag returns (reward and non-reward, harvested and released) during the angling season following tagging (May 15, 2004 to February 28, 2005). Percent of total recaptured fish is in parentheses.

	Recapture location				
Tagging location	Peavy Pond	N. Michigamme River	S. Michigamme River	Paint River	Lake Mary
Peavy Pond	197 (91.2)	4 (1.8)	12 (5.6)	2 (0.9)	1 (0.5)
N. Michigamme River	1 (50.0)	0 (0)	1 (50.0)	0 (0)	0 (0)
S. Michigamme River	2 (50.0)	0 (0)	2 (50.0)	0 (0)	0 (0)
Paint River	0 (0)	0 (0)	0 (0)	1 (100)	0 (0)

Table 14.–Angler survey estimates for summer 2004 from Peavy Pond. Survey period was from May 8 through October 31, 2004. Catch per hour is harvest and release rate, respectively (fish per hour). Two standard errors are given in parentheses.

Species	Catch per hour	Month May	Jun	Jul	Aug	Sep	Oct	Season
		Number harvested						
Smallmouth bass	0.0113	8	83	57	54	42	12	255
	(0.0049)	(15)	(60)	(48)	(47)	(44)	(16)	(103)
Walleye	0.0298	107	126	168	162	89	18	670
	(0.0096)	(96)	(67)	(91)	(90)	(61)	(20)	(185)
Yellow perch	0.1554	140	270	925	1,168	787	212	3,501
	(0.0501)	(158)	(147)	(418)	(730)	(369)	(164)	(958)
Northern pike	0.0178	84	84	95	78	46	15	402
	(0.0071)	(83)	(54)	(60)	(75)	(38)	(15)	(144)
Black crappie	0.0132	152	89	26	12	0	18	297
	(0.0076)	(147)	(62)	(23)	(14)	(0)	(32)	(165)
Bluegill	0.0169	49	290	7	6	27	2	380
	(0.0172)	(58)	(375)	(13)	(13)	(33)	(3)	(381)
Largemouth bass	0.0005	0	0	0	0	11	0	11
	(0.0010)	(0)	(0)	(0)	(0)	(22)	(0)	(22)
Pumpkinseed	0.0003	0	0	0	0	6	0	6
	(0.0005)	(0)	(0)	(0)	(0)	(12)	(0)	(12)
Rock bass	0.0199	15	113	79	146	75	20	449
	(0.0098)	(24)	(70)	(69)	(162)	(74)	(20)	(206)
Total harvested	0.2651	554	1,056	1,357	1,626	1,083	297	5,972
	(0.0663)	(258)	(426)	(441)	(759)	(388)	(171)	(1,095)
		Number released						
Smallmouth bass	0.0468	23	245	141	166	446	33	1,054
	(0.0158)	(37)	(152)	(77)	(96)	(231)	(36)	(307)
Largemouth bass	0.0005	3	3	0	3	0	3	11
	(0.0005)	(6)	(5)	(0)	(5)	(0)	(6)	(11)
Walleye	0.0898	61	248	485	471	724	34	2,023
	(0.0348)	(59)	(178)	(228)	(236)	(591)	(49)	(703)
Northern pike	0.1214	244	596	676	584	602	34	2,736
	(0.0351)	(231)	(316)	(298)	(295)	(284)	(32)	(641)
Muskellunge	0.0005	7	0	2	1	0	0	10
	(0.0007)	(14)	(0)	(5)	(2)	(0)	(0)	(15)
Common white sucker	0.0002	0	3	2	0	0	0	6
	(0.0004)	(0)	(7)	(4)	(0)	(0)	(0)	(8)
Rock bass	0.0384	15	305	247	166	114	18	865
	(0.0150)	(31)	(199)	(141)	(114)	(132)	(27)	(303)
Bluegill	0.0033	45	3	0	9	17	0	74
	(0.0033)	(68)	(7)	(0)	(18)	(24)	(0)	(74)
Pumpkinseed	0.0002	0	0	0	0	4	0	4
	(0.0004)	(0)	(0)	(0)	(0)	(8)	(0)	(8)
Yellow perch	0.0580	20	254	246	376	398	13	1,307
	(0.0220)	(27)	(226)	(142)	(254)	(244)	(19)	(443)
Total released	0.3592	418	1,658	1,800	1,777	2,304	135	8,091
	(0.0792)	(254)	(496)	(432)	(480)	(749)	(77)	(1,138)
Total (harvested + released)	0.6242	971	2,713	3,157	3,403	3,387	431	14,063
	(0.1272)	(362)	(654)	(617)	(898)	(844)	(188)	(1,579)
Angler hours		4,174	4,211	4,867	4,215	4,011	1,050	22,527
		(2,855)	(1,182)	(1,084)	(1,527)	(1,159)	(516)	(3,829)
Angler trips		689	824	1,064	1,021	926	247	4,770
		(525)	(298)	(387)	(662)	(351)	(129)	(1,045)

Table 15.–Angler survey estimates for winter from Peavy Pond. Survey period was from December 16, 2004 through February 28, 2005. Catch per hour is harvest and release rate, respectively (fish per hour). Two standard errors are given in parentheses.

Species	Catch per hour	December	January	February	Season
		Number harvested			
Walleye	0.0307	32	47	41	120
	(0.0197)	(32)	(40)	(32)	(60)
Yellow perch	0.0334	16	70	45	131
	(0.0273)	(25)	(70)	(56)	(93)
Northern pike	0.0193	30	25	21	76
	(0.0155)	(36)	(32)	(22)	(53)
Total harvested	0.0834	78	143	107	327
	(0.0457)	(54)	(87)	(68)	(123)
		Number released			
Walleye	0.0187	8	28	37	73
	(0.0130)	(14)	(25)	(31)	(42)
Northern pike	0.0712	86	90	103	279
	(0.0628)	(144)	(145)	(79)	(220)
Yellow perch	0.0057	0	2	21	22
	(0.0108)	(0)	(4)	(41)	(41)
Total released	0.0957	95	120	161	375
	(0.0694)	(145)	(148)	(94)	(227)
Total (harvested + released)	0.1791	172	262	268	702
	(0.0972)	(155)	(171)	(116)	(259)
Angler hours		1,135	1,236	1,549	3,920
		(1,086)	(780)	(807)	(1,562)
Angler trips		222	290	341	853
		(215)	(201)	(198)	(355)

Table 16.–Comparison of recreational fishing effort and total harvest on Peavy Pond to estimates from other selected Michigan lakes. Lakes are listed from highest to lowest total fishing effort.

Lake	County	Size (acres)	Survey period	Fishing effort (hours)	Fish harvested (number)	Fish harvested per hour	Hours fished per acre	Fish harvested per acre
Houghton	Roscommon	20,075	Apr 2001–Mar 2002	499,048	386,287	0.77	24.9	19.2
Cisco Chain	Gogebic, Vilas	3,987	May 2002–Feb 2003	180,262	120,412	0.67	45.2	30.2
Muskegon	Muskegon	4,232	Apr 2002–Mar 2003	180,064	184,161	1.02	42.5	43.5
Burt	Cheboygan	17,395	Apr 2001–Mar 2002	134,205	68,473	0.51	7.7	3.9
South Manistique	Mackinac	4,133	May 2003–Mar 2004	142,686	43,654	0.31	34.5	10.6
Lake Leelanau	Leelanau	8,607	Apr 2002–Mar 2003	112,112	15,464	0.14	13.0	1.8
Big Manistique	Luce, Mackinac	10,346	May 2003–Mar 2004	88,373	71,652	0.81	8.5	6.9
Black Lake	Cheboygan, Presque Isle	10,113	Apr 2005–Mar 2006	59,874	18,762	0.31	5.9	1.9
Charlevoix	Charlevoix	17,268	Apr 2006–Mar 2007	57,126	19,671	0.34	3.3	1.1
Crooked and Pickerel	Emmet	3,434	Apr 2001–Mar 2002	55,894	13,665	0.24	16.3	4.0
Michigamme Reservoir	Iron	6,400	May 2001–Feb 2002	52,686	10,899	0.21	8.2	1.7
Long	Presque Isle, Alpena	5,342	Apr 2004–Mar 2005	34,894	7,004	0.20	6.5	1.3
Grand	Presque Isle	5,822	Apr 2004–Mar 2005	33,037	10,623	0.32	5.7	1.8
Peavy Pond	Iron	2,347	May 2004–Feb 2005	26,447	6,299	0.24	9.5	2.3
Bond Falls Flowage	Ontonagon	2,127	May–Oct 2003	21,182	3,193	0.15	10.0	1.5
North Manistique	Luce	1,709	May 2003–Mar 2004	10,614	7,603	0.72	6.2	4.4
Average				105,532	61,739	0.44	15.5	8.5
Median				58,500	17,113	0.32	9.0	3.1

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Troy G. Zorn, Reviewer
William Ziegler, Reviewer
Robert Haas, Editor
Ellen S. Grove, Desktop Publisher
Alan D. Sutton, Graphics

Approved by Tammy J. Newcomb

Appendix

Appendix–Fish species collected in Peavy Pond 1987 through 2004.

Common name	Scientific name
Species collected in spring 2004 with fyke nets and electrofishing	
Black bullhead	*Ameiurus melas*
Black crappie	*Pomoxis nigromaculatus*
Bluegill	*Lepomis macrochirus*
Brook trout	*Salvelinus fontinalis*
Burbot	*Lota lota*
Common shiner	*Luxilus cornutus*
Creek chub	*Semotilus atromaculatus*
Golden shiner	*Notemigonus crysoleucas*
Lake whitefish	*Coregonus clupeaformis*
Largemouth bass	*Micropterus salmoides*
Mottled sculpin	*Cottus bairdi*
Muskellunge	*Esoc masquinongy*
Northern pike	*Esox lucius*
Pumpkinseed	*Lepomis gibbosus*
Rock bass	*Ambloplites rupestris*
Smallmouth bass	*Micropterus dolomieu*
Tadpole madtom	*Noturus gyrinus*
Tiger muskellunge	*Esox lucius x Esox masquinongy*
Walleyes	*Sander vitreus*
White sucker	*Catostomus commersonii*
Yellow perch	*Perca flavescens*
Additional species collected in fall 1987 with electrofishing	
Logperch	*Percina caprodes*
Johnny darter	*Etheostoma nigrum*