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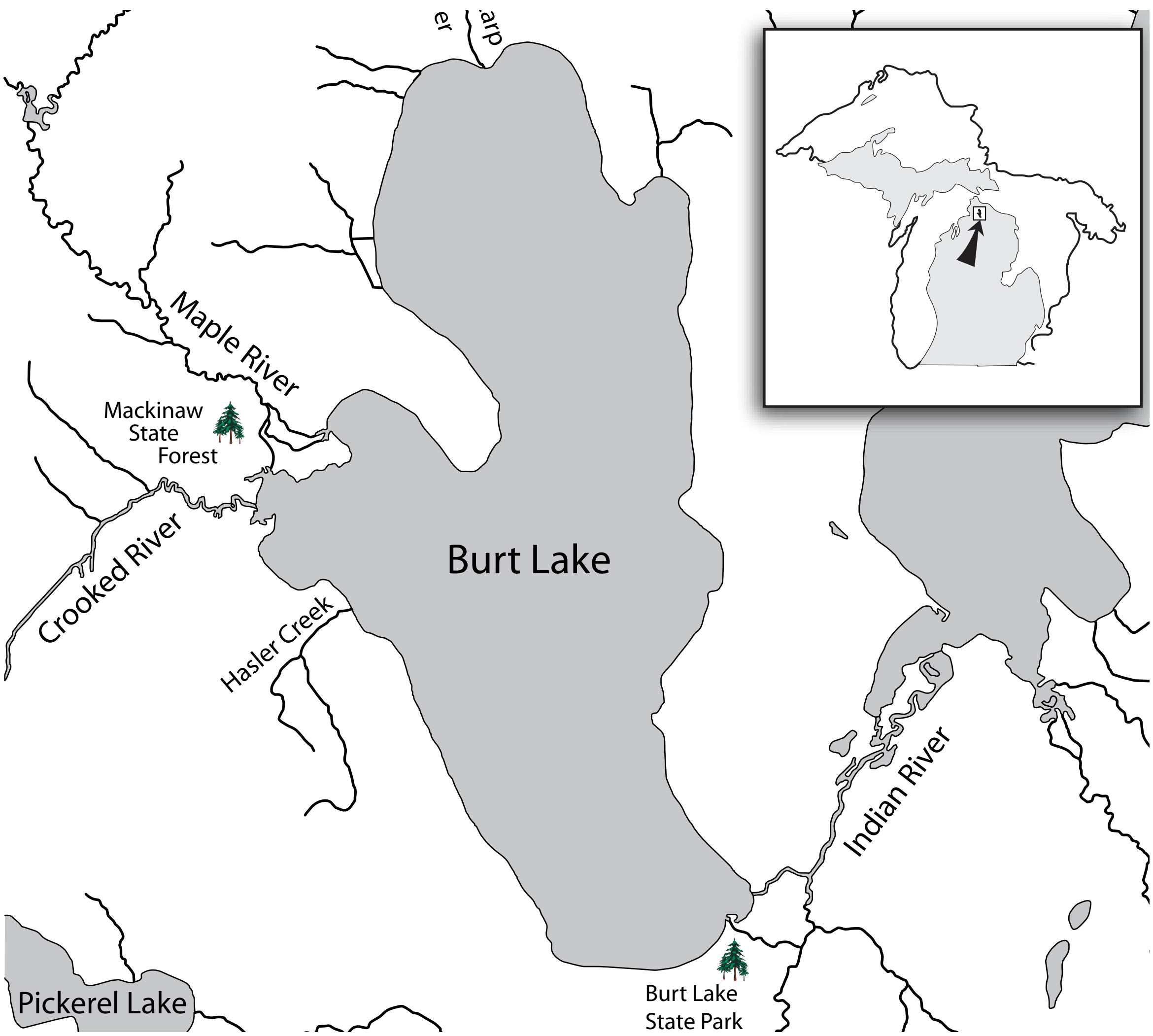
# The Fish Community and Fishery of Burt Lake, Cheboygan County, Michigan in 2001–02 with Emphasis on Walleyes and Northern Pike


**Patrick A. Hanchin, Richard D. Clark, Jr., Roger N. Lockwood, and Tim Cwalinski**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# FISHERIES DIVISION
# SPECIAL REPORT 36

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**FISHERIES DIVISION**

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## Table of Contents

*Michigan Department of Natural Resources*
*Fisheries Special Report 36, 2005*

# The Fish Community and Fishery of Burt Lake, Cheboygan County, Michigan in 2001-02 with Emphasis on Walleyes and Northern Pike

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## Introduction

Michigan Department of Natural Resources (MDNR), Fisheries Division surveyed fish populations and angler catch and effort at Burt Lake, Cheboygan County, Michigan from April 2001 through March 2002. This work was part of a statewide program designed to improve assessment and monitoring of fish communities and fisheries in Michigan's largest inland lakes. Known as the Large Lakes Program, it is currently scheduled to survey about four lakes per year over the next ten years (Clark et al. 2004).

The Large Lakes Program has three primary objectives. First, we want to produce consistent indices of abundance and estimates of annual harvest and fishing effort for important fishes. Initially, important fishes are defined as species susceptible to trap or fyke nets and/or those readily harvested by anglers. Our hope is to produce statistics for important fishes to help detect major changes in their populations over time. Second, we want to produce sufficient growth and mortality statistics to be able to evaluate effects of fishing on special-interest species which support valuable fisheries. This usually involves targeting special-interest species with nets or other gears to collect, sample, and mark sufficient numbers. We selected walleyes *Sander vitreus* and northern pike *Esox lucius* as special-interest species in this survey of Burt Lake. Finally, we want to evaluate the suitability of various statistical estimators for use in large lakes. For example, we applied and compared three types of abundance and two types of exploitation rate estimators for walleyes and northern pike in this survey of Burt Lake.

The Large Lakes Program will maintain consistent sampling methods over lakes and time. This will allow us to build a body of fish population and harvest statistics to directly evaluate differences between lakes or changes within a lake over time. Burt Lake is only the fourth lake to be sampled under the protocols of the program, thus, we were sometimes limited in our ability to make valid comparisons. Of course, as our program progresses we will eventually have a large body of netting data collected under the same conditions in the future.

## Study Area

The size of Burt Lake is about 17,000 acres, with sources disagreeing only slightly on size. Humphrys and Green (1962) estimated 17,120 acres for Burt Lake by taking measurements from United States Geological Survey (USGS) topographical maps using hand-held drafting tools. Michigan Digital Water Atlas[1] (2003) reported 17,394 acres for Burt Lake by using computerized digitizing equipment and USGS topographical maps. They overlaid the boundaries of the lake polygon from the MDWA GIS layer with aerial photos of the lake using ArcView©, and the two matched well. In our Large Lakes Program, we want to compare various measures of productivity among lakes, such as number of fish per acre or harvest per acre, so a measure of lake size is important. Therefore in our analyses, we will use the more modern estimate of 17,394 acres as the size of Burt Lake.

Burt Lake is fed by Crooked and Maple rivers on the west shore (Figure 1) and the Sturgeon River on the south shore. Other tributaries that enter the lake include the Little Carp River, Hasler Creek, and various small unnamed streams. The Little Carp, Maple, and Sturgeon rivers are designated Michigan trout streams. Burt Lake is part of the Inland Waterway, a historically important boating route across Northern Michigan between lakes Michigan and Huron. From Lake Michigan, the route goes through Little Traverse Bay and Round Lake, then enters the Lake Huron drainage after a short portage to Pickerel Lake. It continues through Crooked Lake, the Crooked River, Burt Lake, the Indian River, Mullet Lake, and finally through the Cheboygan River to Lake Huron.

The shoreline is largely developed with private and commercial residences, but some public riparian land exists in the form of a state forest and state park (Figure 1). The maximum depth of Burt Lake is about 73 ft. The bathymetry is variable, with both shallow flats and deep holes. Most of the lake, however, is less than 40 ft deep. Percent area and percent volume by depth are presented in Figures 2 and 3. Substrate in shallow areas consists of sand, marl, rock, and gravel, while substrate in deeper water is sand and organic matter. Aquatic vegetation is typically sparse and located in the shallower, northern end of the lake and near the confluence of the Maple and Indian rivers.

The most complete water chemistry analyses on Burt Lake were done in 1955. There were two stations that were sampled over 7 days through July and August. Summer dissolved oxygen concentrations (ppm) averaged 7.3 at the surface, and decreased with increasing depth. Generally, dissolved oxygen was below 6.0 ppm only at depths greater than 30 ft. Dissolved oxygen concentrations ranged from 0.2–1.0 at depths greater than 50 ft. Surface water temperature averaged 75.9°F during these summer months, and it gradually declined to an average of 64.6°F at the bottom. Borgeson (MDNR, unpublished data) reported an alkalinity of around 150 mg/l $CaCO_3$ for Burt Lake.

The fish community of Burt Lake includes species typical of northern Michigan. We listed common and scientific names of all fish species captured during this study in the Appendix. Henceforth, we will refer to fishes only by common name in the text. Families of fish include, but are not limited to, *Amiidae, Cyprinidae, Catostomidae, Centrarchidae, Esocidae, Ictaluridae, Lepisosteidae, Percidae, and Salmonidae*. Previous surveys of the walleye population have generally

[1] A statewide program conducted by MDNR, Fisheries Division, Lansing to develop computerized maps and reference data for aquatic systems in Michigan. (http://ifrgis.snre.umich.edu/dwa/introduction.html)

characterized them as having average recruitment, growth, and size structure. Burt Lake walleyes typically reach legal size (≥ 15 in) by age 3 or 4. Burt Lake northern pike have generally been characterized by low recruitment, with average growth and size structure. Prey species include but are not limited to: white suckers, redhorse suckers, panfish, and lake herring. Various panfish species such as yellow perch and rock bass are common in Burt Lake. These two species reach large sizes and produce a popular fishery. Panfish such as bluegill, black crappie, and pumpkinseed are less common but present.

Fish stocking in Burt Lake has involved a variety of species, ages, and sizes dating back to 1925. Lake whitefish were stocked on three occasions from 1927–1931. Rock bass were stocked on seven occasions from 1936–1948. Yellow perch were stocked on thirteen occasions from 1928–1947 while northern pike were stocked in 1948 and 1949. Lake sturgeon were stocked in Burt Lake from 1983–1984, and in 1990. Brook trout were stocked in 1943, while lake trout were stocked in 1925 and 1927. Burt Lake has received many strains of rainbow trout from 1928 through 1987. Known walleye stocking efforts began in Burt Lake in 1933 and continued intermittently through 1949. Recently, walleye fingerlings were again stocked from 1989 through 1993 (Table 1), although the number of fish stocked was not significant on a per-acre basis. These were the only walleyes stocked in Burt Lake between 1980 and 2001. Fingerling stocking efforts may have augmented the walleye population slightly.

There have been 68 State of Michigan Master Angler awards taken from Burt Lake between 1990 and 2001 (Table 2), including black crappie, rock bass, smallmouth bass, white bass, yellow perch, and muskellunge.

## Methods

We used the same methods on Burt Lake as described by Clark et al. (2004) for Houghton Lake. We will give a complete overview of methods in this report, but will refer the reader to Clark et al. (2004) for details.

Briefly, we used nets and electrofishing gear to collect fish in April–May to coincide with spawning of primary targets – walleyes and northern pike. All fish captured were identified to species and counted. Fishing effort was recorded by individual net lift, but electrofishing effort was not standardized. Electrofishing was only used to increase the number of walleyes and northern pike tagged. Total lengths were measured for sub-samples of each non-target species. All walleyes and northern pike were measured and legal-size fish were tagged with individually numbered jaw tags. Tagged fish were also fin clipped to evaluate tag loss. Angler catch and harvest surveys were conducted the year after tagging; one covering the summer fishery from April 28 through September 30, 2001 and one covering the winter fishery from January 1 through March 31, 2002. Tags on walleyes and northern pike observed during angler surveys were tallied and the ratios of marked to unmarked fish were used to make abundance estimates for walleyes and northern pike. In addition, voluntary tag recoveries were requested. All tags contained a unique number and the mailing address of an MDNR field station. To encourage voluntary tag returns, about 50% of tags were identified as reward tags, and we paid $10 to anglers returning them.

### *Fish Community*

We described the status of the overall fish community in terms of species present, catch per unit effort, percent by number, and size distribution. We also collected more detailed data for walleyes and northern pike as described below. We sampled fish populations in Burt Lake with trap nets, fyke nets, and electrofishing gear from April 19 to May 9, 2001. We used three boats daily to work nets, each with three-person crews, for 3 weeks. Each net-boat crew tended about 10 nets per day. Night electrofishing runs were also made occasionally.

Fyke nets were 6 ft x 4 ft with 2-in stretch mesh and 90- to 98-ft leads. Trap nets were 8 ft by 6 ft by 3 ft with 2-in stretch mesh and 90- to 98-ft leads. Duration of net sets ranged from 1–2 nights, but most were 1 night. We used a Smith-Root® boat equipped with boom-mounted electrodes (DC) for electrofishing. Latitude and longitude were recorded for all net locations and electrofishing runs using GPS.

We identified species and counted all fish captured. For non-target species, we measured lengths to the nearest 0.1 in for sub-samples 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. We used Microsoft Access© to store and retrieve data collected during the tagging operation. Size distribution data only included fish on their initial capture occasion. We recorded mean catch per unit effort (CPUE) in fyke nets and trap nets as indicators 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).

Schneider (2000) 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, some indices of species composition might provide useful insight into fish community dynamics. As one possible index, we calculated the percents by number of fish we 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. Perhaps, such an index will prove a useful way to compare fish communities between lakes or within the same lake over time, especially in the future when more large lake surveys using similar methods are available for comparison.

### *Walleyes and Northern Pike*

*Size structure*.–All walleyes and northern pike were measured to the nearest 0.1 in. Size structure was characterized for purposes of comparison using percent over legal size.

*Sex composition.*–We recorded sex of walleyes and northern pike. Fish with flowing gametes were categorized as male or female, respectively. Fish with no flowing gametes were categorized as unknown sex.

*Abundance.*–We estimated abundance of legal-size walleyes and northern pike using mark-and-recapture methods. Walleyes (≥ 15 in) and northern pike (≥ 24 in) were fitted with monel-metal jaw tags. In order to assess tag loss, we double-marked each tagged fish by clipping the left pelvic fin. Reward ($10) and non-reward tags were issued in an approximate 1:1 ratio. 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 concern for netting-induced tag loss. All fish that lost tags during netting recapture were re-tagged, and so were accounted for in the total number of marked fish at large.

We compared two different abundance estimates 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).

For the multiple-census estimate, we used the Schumacher-Eschmeyer formula (± 95% asymmetrical confidence limits) from daily recaptures during the tagging operation (Ricker 1975). The minimum number of recaptures necessary for an unbiased estimate was set a priori at four. For the single-census estimate, we used numbers of marked and unmarked fish seen by creel clerks in the companion angler survey as the “recapture-run” sample. The Chapman modification of the Petersen method (Ricker 1975) was used to generate population estimates (± 95% symmetrical confidence limits). Probability of tag loss was calculated as the number of fish in a recapture sample with fin clips 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). If we detected annual tag loss, we adjusted the single-census abundance estimate by reducing the number of marked fish at large. For more details on methods for abundance estimates, see Clark et al. (2004).

No prior abundance estimates existed for either walleyes or northern pike in Burt Lake to help us gauge how many fish to mark. For walleyes, we used a regression equation developed for Wisconsin lakes (Hansen 1989) to provide an a priori estimate of abundance. This regression predicts adult walleye abundance based on lake size. Parameters for this equation are re-calculated every year by Wisconsin Department of Natural Resources (WDNR). We used the same parameters used by WDNR in 2001 (Doug Beard, WDNR, personal communication):

$$\ln(N) = 1.6106 + 0.9472 \times \ln(A),$$

where $N$ is the estimated number of walleyes and $A$ is the surface area of the lake in acres. This equation was derived from abundance estimates on 179 lakes in northern Wisconsin. For Burt Lake, the equation gives an estimate of 52,012 walleyes, with a 95% confidence interval of 16,820 to 160,830. The ‘confidence interval’ here is more precisely a prediction interval with 95% confidence (Zar 1999).

We determined our tagging goal by evaluating the effect of increasing the proportion tagged on the precision of the estimate (Clark et al. 2004). Based on this analysis, it was our judgment that marking 10% of the population achieved a good compromise between marking effort and precision, assuming the fraction marked was a function of marking effort (Figure 4). Thus, we set our tagging goal at 10% of the population or approximately 5,000 walleyes. We set no specific tagging goal for northern pike. We simply tagged as many northern pike as possible until the walleye goal was achieved.

It is important to recognize the difference between walleye abundance estimates from the Wisconsin regression equation and walleye abundance estimates we made. The Wisconsin equation predicts abundance of adult walleyes on the spawning grounds, while our primary, single-census estimate was only for walleyes ≥ 15 in. Wisconsin defined adult walleyes as legal size, or sub-legal of identifiable sex. Because we clipped fins and recorded recaptures of all walleyes, we were also able to make a direct multiple-census estimate of adult walleyes for comparison using the Schumacher-Eschmeyer formula and including the sub-legal and mature fish that were marked and recaptured.

We estimated numbers of adult walleyes from our single-census estimate by dividing our estimate of walleyes ≥ 15 by the proportion of adult walleyes on the spawning grounds that were ≥ 15 in, using the equation in Clark et al. (2004).

Similar to walleyes, we defined adult northern pike as those ≥ 24 in or <24 in, but of identifiable sex. We estimated adult northern pike using the multiple-census and adjusted single-census methods as was done for walleyes.

We accounted for fish that recruited to legal size over the course of the angler survey by removing a portion of the unmarked fish observed by the creel clerk (i.e., reduced C in the Petersen formula for abundance estimate). Removal of unmarked fish was based on a weighted average monthly growth for fish of slightly sub-legal size (i.e., 14.0–14.9-in walleyes and 22.0–23.9-in northern pike). For a detailed explanation of methods see Ricker (1975) and Clark et al. (2004). This adjusted ratio was used to make the primary (single census) population estimate.

The reliability of all abundance estimates was assessed using the coefficient of variation (CV; standard deviation/mean). Following the methods of Hansen et al. (2000), we considered abundance estimates with a CV ≤ 0.40 to be reliable.

*Mean lengths at age.*–We used dorsal spines to age walleyes and dorsal fin rays to age northern pike. We used these structures because we thought they provided the best combination of ease of collection in the field, and accuracy and precision of age estimates. Clark et al. (2004) described advantages and disadvantages of various body structures for aging walleyes and northern pike.

Sample sizes for age analysis were based on historical length at age data from Burt Lake and methods given in Lockwood and Hayes (2000). Our goal was to collect 20 male and 20 female walleyes per inch group and 20 male and 20 female northern pike per inch group.

Samples were sectioned using a table-mounted Dremel® rotary cutting tool. Sections approximately 0.5-mm thick were cut as close to the proximal end of the spine or ray as possible. Sections were examined at 40x-80x with transmitted light, and were photographed with a digital camera. The digital image was archived for multiple reads. We aged approximately 15 fish per sex per inch group. Two technicians independently aged walleyes. Ages were considered correct when results of both technicians agreed. Samples in dispute were aged by a third technician. Disputed ages were considered correct when the third technician agreed with one of the first two. Samples were discarded if three technicians disagreed on age, but 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, weighted mean lengths at age and age-length keys (Devries and Frie 1996) were computed for males, females, and all fish (males, females, and fish of unknown sex) for both walleyes and northern pike.

We compared our mean lengths at age to those from previous surveys of Burt Lake and other large lakes. Also, we computed a mean growth index to compare our data to Michigan state averages as described by Schneider et al. (2000). Basically, the mean growth index is the average of deviations between the observed mean length and the quarterly statewide average length. In addition, we fit mean length at age data to a von Bertalanffy growth equation using nonlinear regression, and calculated the total length at infinity ($L_\infty$) for use as an index of growth potential. All growth curves were forced through the origin. The total length at infinity is a mathematically-derived number representing the length that an average fish approaches if it lives to age infinity, and grows according to the von Bertalanffy curve (Ricker 1975).

*Mortality.*–We estimated instantaneous total mortality rates using a catch-curve regression (Ricker 1975). We used age groups where the majority of fish in each age group were sexually mature, recruited to the fishery (≥ minimum size limit), and represented on the spawning grounds in proportion to their true abundance in the population. For a more detailed explanation of age group selection criteria see Clark et al. (2004). When sufficient data were available, we computed separate catch curves for males and females to determine if total mortality differed by sex. A catch curve was also computed for all fish that included males, females, and fish of unknown sex.

We estimated angler exploitation rates using two methods: 1) the percent of reward tags returned by anglers; and 2) the estimated harvest divided by estimated abundance. We compared these two estimates of exploitation and converted them to instantaneous fishing mortality rates.

In the first method, exploitation rate was estimated as the fraction of reward tags returned by anglers adjusted for tag loss. We did not assess tagging mortality or incomplete reporting of reward tags. We made the assumption that tagging mortality was negligible and that near 100% of reward tags would be returned.

Voluntary tag returns were encouraged with a monetary reward ($10) denoted on approximately one half of the tags. Tag return forms were made available at boater access sites, at MDNR offices, and from creel clerks. Additionally, tag return information could be submitted on-line at the MDNR website. All tag return data were entered into the database so that it could be efficiently linked to and verified against data collected during the tagging operation. Return rates were calculated separately for reward and non-reward tags.

In the second method, we calculated exploitation as the estimated annual harvest from the angler survey divided by the estimated abundance of legal-size fish from the single-census abundance estimate. For proper comparison with the 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 (Clark et al. 2004).

*Recruitment.*–We considered relative year-class strength as an index of 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, and 1987; Madenjian et al. 1996; and 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. In addition, walleye stocking can affect year-class strength, but stocking success is highly variable, depending on the size and number of fish stocked, level of natural reproduction occurring, and other factors (Laarman 1978; Fielder 1992; Li et al. 1996a; Li et al. 1996b; and Nate, et al. 2000).

We obtained population data in Burt Lake for only one year, and so could not rigorously evaluate year-class strength. However, we suggest that valuable insight about the relative variability of recruitment can be gained by examining the properties of our 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.

As Maceina (2003), we will assume the residuals of our catch-curve regressions were indices of year-class strength. For walleyes, we used correlation analysis and linear regression between catch-curve residuals and environmental variables to determine if there was a relationship. Additionally, we used the approach of Isermann et al. (2002) and calculated the recruitment coefficient of determination (RCD) to index recruitment variability.

*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, we identified conspicuous movement such as to another lake or connected river.

### *Angler Survey*

Fishing harvest seasons for walleyes and northern pike during this survey were April 28, 2001–March 15, 2002. Minimum size limits were 15 in for walleyes and 24 in for northern pike. Daily bag limit was 5 fish of any combination of walleyes, northern pike, smallmouth bass, and largemouth bass.

Fishing harvest seasons for smallmouth bass and largemouth bass were May 26, 2001 through Dec 31. Minimum size limit was 14 in for both smallmouth bass and largemouth bass.

Harvest was permitted all year for all other species present. No minimum size limits were imposed for other species. Bag limit for yellow perch was 50 per day. Bag limit for “sunfishes”, including black crappie, bluegill, pumpkinseed, and rock bass was 25 per day in any combination.

Direct contact angler creel surveys were conducted during one spring-summer period – April 28 to September 30, 2001, and one winter period – January 1, 2002 through March 31, 2002. Ice cover in the winter requires different methods from the summer surveys.

*Summer.*–We used an aerial-roving design for the summer survey (Lockwood 2000b). Fishing boats were counted by aircraft and one clerk working from a boat collected angler interview data. The survey period was from April 28 through September 30, 2001. Both weekend days and three randomly selected weekdays were selected for counting and interviewing during each week of the survey season. No interview data were collected on holidays; however, aerial counts were made on holidays. Holidays during the period were Memorial Day (May 28, 2001), Independence Day (July 4, 2001), and Labor Day (September 3, 2001). Counting and interviewing were done on the same days (with exception to previously discussed holidays), and 1 instantaneous count of fishing boats was made per day. For sampling purposes, Burt Lake was divided into separate sections (Figure 5). All count and interview data were collected and recorded by section. Similarly, effort and catch estimates were made by section and summed for lake-wide estimates.

Two different aerial counting paths were used (Figures 6 and 7), selection of which was randomized. The pilot flew one of the two randomly selected predetermined routes using GPS coordinates. Each flight was made at 500–700 ft elevation and took approximately 15 min to complete with air speed of about 85 mph. Counting was done by the contracted pilot and only fishing boats were counted (i.e., watercrafts involved in alternate activities, such as water skiing, were not counted). Time of count was randomized to cover daylight times within the sample period. Count information for each count was recorded on a lake map similar to Figure 5. This information included: date, count time, and number of fishing boats in each section.

Minimum fishing time prior to interview (incomplete-trip interview) was 1 h (Lockwood 2004). Historically, minimum fishing time prior to interviewing has been 0.5 h (Pollock et al. 1997). However, recent evaluations have shown that roving interview catch rates from anglers fishing a minimum of 1 h are more representative of access interview (completed-trip interview) catch rates (Lockwood 2004). Access interviews include information from complete trips and are appropriate standards for comparison.

All roving interview data were collected by individual angler to avoid party size bias (Lockwood 1997). When all anglers within a section were interviewed during a sample day, the clerk roamed the remaining sections interviewing anglers.

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, section, 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 and northern pike, and applicable tag number. Catch and release of smallmouth bass, largemouth bass, walleyes, and northern pike, and muskellunge were recorded. Number of anglers in each party was recorded on one interview form for each party.

One of two shifts was selected each sample day for interviewing (Table 3). Interview starting location (section) and order were randomized daily. Interview forms, information, and techniques used during the summer survey period were the same as those used during the winter survey period. When anglers reported fishing in more than one section, the clerk recorded the section where they spent most of that trip fishing.

*Winter.*–We used a progressive-roving design for winter surveys (Lockwood 2000b). One clerk working from a snowmobile collected count and interview data. Both weekend days and 3 randomly selected weekdays were selected for sampling during each week of the survey season. No holidays were sampled. Holidays during the winter sampling period were: New Year's Day (January 1, 2002), Martin Luther King Day (January 15, 2002), and President's Day (February 19, 2002). The clerk followed a randomized count and interview schedule. One of two shifts was selected each sample day (Table 3). Burt Lake was divided into separate sections (Figure 8). All count and interview data were collected and recorded by section. Similarly, effort and catch estimates were made by section and summed for lake-wide estimates. Starting location (section) and direction of travel were randomized for both counting and interviewing. Scanner-ready interview and count forms were used.

Progressive (instantaneous) counts of open-ice anglers and occupied shanties were made once per day. Count information collected included: date, section, fishing mode (open ice or shanty), count time, and number of units (anglers or occupied shanties) counted.

Similar to summer interview methods, minimum fishing time prior to interviewing was 1 h. When anglers reported fishing in more than one section, the clerk recorded the section where they spent most of that trip fishing. No anglers were interviewed while counting (Wade et al. 1991). Additional interviewing instructions and interview information collected followed methods for the summer survey period.

*Estimation methods.*–Catch and effort estimates were made by section using a multiple-day method (Lockwood et al. 1999). Expansion values ("F" in Lockwood et al. 1999) are given in Table 3. These values are the number of hours within sample days. Effort is the product of mean counts by section for a given period day type, days within the period, and the expansion value for that period. Thus, the angling effort and catch reported here are for those periods sampled, no expansions were made to include periods not sampled (e.g., 0100 to 0400 hours). Lake-wide estimates were the sum of section estimates for each given time period and day type.

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 for a section) 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 and section) 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:

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

where $\hat{R}$ is the ratio-of-means estimator for $n_1$ interviews and $\overline{R}$ the mean-of-ratios estimator for $n_2$ interviews. Estimated variance $s_w^2$ was calculated as:

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

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

From the angler creel data collected, catch and harvest by species were estimated and angling effort expressed as 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 (MDNR Fisheries Division – unpublished data).

All estimates are given with 2 SE. Error bounds (2 SE), provided statistical significance, assuming normal distribution shape and $N \geq 10$, of 75% to 95% (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.

As a routine part of interviewing, the creel clerk recorded presence or absence of jaw tags and fin clips, tag numbers, and lengths of walleyes and northern pike. These data were used to estimate tag loss and to determine the ratio of marked-unmarked fish for single-census abundance estimates.

## Results [2]

### *Fish Community*

We collected a total of 17,227 fish of 28 species (Table 4). Total sampling effort was 321 trap-net lifts, 31 fyke-net lifts and 6 electrofishing runs. We captured 2,899 walleyes and 203 northern pike.

Other game species collected in order of abundance of total catch were: rock bass, smallmouth bass, yellow perch, rainbow trout, brown trout, largemouth bass, pumpkinseed, bluegill, black crappie, muskellunge, and brook trout.

Rock bass comprised 19% of the catch by number. Mean length of this species was 7.5 in. Sixty-five percent of the rock bass collected were 8-in or larger in size (Table 5). Yellow perch were collected more readily than the remaining panfish with 37% 10-in or larger (Table 5). Yellow perch mean length was 8.9 in. Other panfish including bluegill, pumpkinseed, and black crappie were caught in low numbers during the survey.

Smallmouth bass are abundant in Burt Lake, representing 8% of the total catch by number. Sixty-two percent of those collected were legal size. Largemouth bass are present in Burt Lake, yet rather uncommon based on survey catches.

Suckers are common in Burt Lake (Table 4) and comprise a large portion of the fish biomass. Other common non-game fish included a variety of bullhead species and bowfin. Less common non-game species included burbot, carp, and gar (Table 4).

The overall fish community composition in Burt Lake was 26% piscivores, 20% pelagic planktivores-insectivores, and 54% benthivores (Table 4). Of the species we collected, we classified walleyes, northern pike, smallmouth bass, largemouth bass, bowfin, longnose gar, burbot, brown trout, muskellunge, and sea lamprey as piscivores; rock bass, bluegill, pumpkinseed, yellow perch, black crappie, lake herring, brook trout, and rainbow trout as pelagic planktivores-insectivores; suckers, bullheads, common carp, and logperch as benthivores.

### *Walleyes and Northern Pike*

*Size structure.*–Size structure of walleyes and northern pike measured in our spring netting and electrofishing catches are presented in Table 5. The percents of walleyes and northern pike that were

[2] We provide confidence limits for various estimates in relevant tables, but not in the text.

legal size was 70 and 35, respectively. This is compared to 53 and 4 for walleyes and pike in adjacent Crooked and Pickerel lakes. The population of spawning walleyes was dominated by 13- to 18- inch walleyes, with some (8%) ≥ 20 in. Most northern pike were 21 to 23 in, but a relatively high proportion (13%) of large pike (≥ 30 in) are also present.

*Sex composition.*–Male walleyes outnumbered females in our spring survey, which is typical for walleyes (Carlander 1997). Of all walleyes captured, 72% were male, 12% were female, and 16% were unknown sex. Of legal-size walleyes captured, 73% were male, 17% were female, and 10% were unknown sex. The sex ratio for northern pike appeared more balanced than walleyes, however many fish were of unknown sex. Of all northern pike captured, 25% were male, 29% were female, and 46% were unknown sex. Of 66 legal-size northern pike captured, 12% were male, 36% were female, and 52% were unknown sex. Male northern pike typically outnumber females in spring spawning surveys (Priegel and Krohn 1975; Bregazzi and Kennedy 1980; Clark et al. 2004).

*Abundance.*–We tagged a total of 1,877 legal-size walleyes in Burt Lake (924 reward and 953 non-reward tags). No walleyes were observed to have lost their tags during the spring netting/electrofishing survey. We also clipped fins of 828 sub-legal walleyes in Burt Lake.

Creel clerks observed a total of 637 walleyes, of which 27 were marked. We reduced the number of unmarked walleyes in the single-census calculation by 138 fish to adjust for sub-legal fish that grew over the minimum size limit during the fishing season. The creel clerk observed one fish that had a fin clip, but no tag. This fish was determined to have been legal size at the time of tagging; thus, it had apparently lost its tag. Based on this sample of 27 re-captured fish, the estimate of tag loss is 3.7%, with a standard error of 0.14%. We believe this estimate of tag loss is reasonable.

The estimated number of legal-size walleyes in Burt Lake was 13,622 using the multiple-census method and 32,295 using the single-census method (Table 6). The estimated number of adult walleyes was 21,832 using the multiple-census method and 42,032 using the single-census method (Table 6). The CVs for all estimates were less than 0.40 and thus were considered reliable.

We tagged a total of 64 legal-size northern pike (27 reward and 37 non-reward tags) and clipped fins of 110 sub-legal northern pike in Burt Lake. No northern pike were observed to have lost their tags during the spring netting/electrofishing survey.

The creel clerk observed 15 northern pike, none of which were tagged. We reduced the number of unmarked northern pike in the single-census calculation by 2 fish to adjust for sub-legal fish that grew over the minimum size limit during the fishing season. There was no tag loss for northern pike observed by the creel clerk.

The estimated number of legal-size northern pike in Burt Lake was 332 using the multiple-census method and 910 using the single-census method (Table 6). The CV's for each method were 0.46 and 0.68, respectively. The estimated number of adult northern pike was 703 using the multiple-census method and 1,779 using the single-census method (Table 6). Corresponding CV's were 0.27 and 0.68, respectively. The only estimate that we considered reliable based on the methods of Hansen (2000) is the multiple-census estimate for adult northern pike.

*Mean lengths at age.*–For walleye, there was 65% agreement between the first two spine readers. For fish that were aged by a third reader, agreement was with first reader 50% of the time and with second reader 50% of the time; thus, there appeared to be no bias among readers. Only 3% of samples were discarded due to poor agreement. An average age was used 2% of the time when ages assigned to older fish (≥ age 10) were within ±10% of each other. At least two out of three readers agreed 95% of the time. Our reader agreement for walleye spines was somewhat higher than other studies. Clark et al. (2004) achieved 53% reader agreement, Hanchin et al. (2005a) found 68%, Isermann et al. (2003) achieved 55%, and Kocovsky and Carline (2000) achieved 62% reader agreement.

For northern pike, there was 59% agreement between the first two spine readers. For fish that were aged by a third reader, agreement was with the first reader 64% of the time and with the second reader 36% of the time; thus, there appeared to be some bias among readers. Most discrepancies in assigned ages were due to identification of the first annulus. Only 4% of samples were discarded due to poor agreement; thus, at least two out of three readers agreed 96% of the time. Clark et al. (2004) found 72% agreement, and Hanchin et al. (2005a) reported 82% agreement between the initial two readers of northern pike fin rays.

Female walleyes had higher mean lengths at age than males after age-3 (Table 7). This dimorphic growth is typical for walleye populations (Colby et al. 1979; Carlander 1997; Kocovsky and Carline 2000). We obtained sufficient sample sizes for a simple comparison of means through age 10. Females were over 5 in longer than males at age 10 (Table 7).

We calculated a mean growth index for Burt Lake walleyes of -0.8 in 2001. Thus, walleyes in our sample from Burt Lake appeared to grow similar to other walleye across Michigan (less than an inch difference). However, this slight negative difference was likely due, at least in part, to biases between aging methods. State average mean lengths were estimated by scale aging which likely underestimates ages as compared to estimates from spines for the same fish (Kocovsky and Carline 2000). If so, this would cause estimated mean lengths at age of scale-aged fish to be larger than spine-aged fish. Eventually, the Large Lakes Program will obtain enough data to recalculate new statewide averages based on spines, which will improve future comparisons.

Mean length at age data for male, female, and all walleyes were fit to a von Bertalanffy growth curve. Male, female, and all walleyes had $L_\infty$ values of 22.0, 24.7, and 22.2 in, respectively.

Female northern pike generally had higher mean lengths at age than males, but sample size for some age groups was low (Table 8). As with walleyes, sexually dimorphic growth is typical for northern pike populations in general (Carlander 1969; Craig 1996).

We calculated a mean growth index for northern pike of -0.2, which means northern pike in our sample from Burt Lake appeared to grow similar to pike across other Michigan water bodies. However, unknown biases associated with use of fin rays for aging makes this result dubious. As with walleyes, the Large Lakes Program will eventually age enough northern pike with fin rays to recalculate state averages for future comparisons.

Mean length at age data for female, and all (males, females, and unknown sex) northern pike were fit to a von Bertalanffy growth curve. Male, female, and all northern pike had $L_\infty$ values of 27.2, 33.0, and 35.9 in, respectively.

*Mortality.*–For walleyes, we estimated catch at age for 1,965 males, 325 females, and 2,742 total walleyes, including those fish of unknown-sex (Table 9). We used ages 4 and older in the catch-curve analysis to represent the legal-size population (Figure 9). We chose age 4 as the youngest age because: 1) average length of walleyes at age 4 was 16.0 in for males and 16.8 in for females (Table 7), so a high proportion of age-4 fish were legal-size at the beginning of fishing season; and 2) relative abundance of fish younger than age 4 do not appear to be represented in proportion to their true abundance (Figure 9; Table 9), suggesting that walleyes (males and females) are not fully mature at age 3. We aged one fish to 20 years, but did not include this age group in the analysis.

The catch-curve regressions for walleyes were all significant ($P < 0.05$), and produced total instantaneous mortality rates for legal-size fish of 0.4482 for males, 0.4087 for females, and 0.4705 for all fish combined (Figure 9). These instantaneous rates corresponded to annual mortality rates of 36% for males, 34% for females, and 38% for all walleyes combined. The estimated mortality for all walleyes combined was greater than for either males or females due to an abundance of young (ages 1 through 4) fish of unknown sex in our samples.

For northern pike, we estimated catch at age for 45 males, 51 females, and 178 total northern pike, including those fish of unknown-sex (Table 9). We used ages 3 through 5 in the catch-curve regression to represent the sub-legal male northern pike population because we aged only 5 fish from age groups where mean lengths were greater than legal size. We used ages 5 through 8 for the catch curve analysis of female northern pike. We chose age 5 as the youngest age because mean length at age 5 was 27.9 in, thus a high proportion of age-5 fish were legal-size at the beginning of fishing season (Figure 10, Table 9). We used ages 4 through 9 in the catch curve analysis for all northern pike. We chose these age groups because a high proportion of age-4 fish are legal-size, and the relative abundance of fish appeared to be represented in proportion to their true abundance (Figure 10, Table 9).

The catch-curve regression of sub-legal male northern pike was not significant, but it resulted in a total instantaneous mortality rate of 0.3580 (Figure 10). The regression for legal female northern pike was not significant, and resulted in a total instantaneous mortality rate of 0.0700. The best catch curve regression was for all northern pike ($P$ = 0.0154), which resulted in a total instantaneous mortality rate of 0.4416. The instantaneous mortality rate for sub-legal males corresponds to a total annual mortality rate of 30%. The instantaneous mortality rate for females was erroneous, and we could not infer a total annual mortality rate from it. Finally, the corresponding total annual mortality rate for all northern pike was 36%.

Anglers returned a total of 161 tags (83 reward and 78 non-reward) from walleyes tagged in Burt Lake in the year following tagging (Table 10). The creel clerk did not observe any tagged fish in the possession of anglers that were not subsequently reported to the central office by the anglers. The estimate of annual exploitation of walleyes was 9.0%. After adjusting for tag loss (3.7%), this estimate increased slightly to 9.3%. Anglers reported both reward and non-reward tags at a similar rate (9.0% versus 8.2%), but they likely did not fully report either one. Angler exploitation of walleyes was 23.0% based on dividing harvest by abundance (Table 6). The harvest estimate used here was first adjusted for non-surveyed months (using tag returns), and second for the proportion of harvested fish that were not of legal size at the time of tagging.

Anglers returned a total of 5 tags (2 reward and 3 non-reward) from northern pike tagged in Burt Lake in the year following tagging (Table 10). The creel clerk did not observe any tagged fish in the possession of anglers that were not reported to the central office by the anglers. The estimated annual exploitation of northern pike based on combined tag returns (reward + non-reward) was 7.8%. Anglers reported both reward and non-reward tags at a similar rate (7.4% versus 8.1%), but they likely did not fully report either one. Angler exploitation was 33.8% based on dividing harvest by abundance (Table 6). We address possible violations to assumptions for exploitation estimates later in the **Discussion** section.

*Recruitment.*–Variability in walleye year-class strength was relatively low in Burt Lake, which can be seen in the statistics of the catch-curve regression. Residual values were small (see scatter of observed values around the regression line for all walleyes in Figure 9) and the amount of variation explained by the age variable (RCD) was high ($R^2$ = 0.93). Burt Lake apparently had similar recruitment variability to Crooked and Pickerel lakes [$R^2$ = 0.94; Hanchin et al. (2005b)], but lower recruitment variability than Houghton Lake [$R^2$ = 0.86; Clark et al. (2004)] and Michigamme Reservoir [$R^2$ = 0.87; Hanchin et al. (2005a)]. Both Crooked and Pickerel lakes and Houghton Lake are stocked with walleyes.

We tested for relationships between the residuals from the catch curve regressions and data taken from the United States Historical Climatology Network (USHCN) weather station in Cheboygan, MI. Variables that we tested included: average monthly air temperature, average monthly minimum air temperature, average monthly maximum air temperature, and average monthly precipitation. We did not find any environmental or climatic variables that were related to walleye year-class strength, but water temperature and water quality data specific to the lake and weather data specific to the region are lacking. Additionally, there was no relationship ($F = 0.6487$, $P = 0.4351$) between the residuals from the catch curve regression and the number of walleyes stocked in Burt Lake, but walleyes were stocked in only five of the fifteen years used in the regression.

For northern pike, variability in year-class strength was relatively high in Burt Lake, which can be seen in the statistics of the catch-curve regression. Some residual values were large (see scatter of observed values around the regression line for all northern pike in Figure 10), and the amount of variation explained by the age variable was relatively low ($R^2 = 0.80$). Clark et al. (2004) reported lower recruitment variability for northern pike in Houghton Lake, Michigan ($R^2 = 0.99$).

*Movement.*–We did not detect any movement of walleyes between lakes (i.e., Burt, Crooked, or Pickerel) during the spring survey. However, since we were not surveying the Indian River, or Mullett Lake, we could not have detected any spring movement to either of those waters.

Based on voluntary tag returns during the year following tagging, there was significant movement of Burt Lake spawning walleyes to other lakes. Of walleyes that were tagged in Burt Lake, 143 (89% of total returns) were reported as caught in Burt Lake, 7 (4%) were reported as caught in Crooked Lake, and 11 (7%) were reported from Mullett Lake.

All northern pike tag returns were reported as caught from Burt Lake.

### *Angler Survey*

*Summer.*–The clerk interviewed 2,933 boating anglers during the summer 2001 survey on Burt Lake. Most interviews (92%) were roving (incomplete-fishing trip). Anglers fished an estimated 85,570 angler hours and made 39,465 angler trips (Table 11).

The total harvest from Burt Lake was 28,627 fish which consisted of nine different species (Table 11). Yellow perch were most numerous with an estimated harvest of 22,243, and no reported releases. Anglers harvested 5,594 walleyes and 246 northern pike, and reported releasing 1,017 walleyes (15% of total catch) and 559 (69% of total catch) northern pike. Anglers harvested 114 smallmouth bass and released 682 (86% of total catch). We do not know what proportion of the released fish was legal size. In future surveys, we recommend distinguishing between sub-legal- and legal-size fish released.

*Winter.*–The clerk interviewed 405 open ice anglers and 380 shanty anglers on Burt Lake. While this survey was designed to collect roving interviews, most open ice (86%) and shanty (76%) interviews were access type (completed trip). Open ice and shanty anglers fished 48,635 angler hours and made 11,865 trips on Burt Lake (Table 12).

A total of 39,466 fish were harvested, comprised of 4 species. Anglers harvested 2,410 walleyes, and reported releasing 756 (24% of total catch). Anglers harvested 50 northern pike, and released 40 (44% of total catch). Anglers also harvested 36,818 yellow perch, and 188 brown trout. A total of 48,658 fish were caught and released, 97% of which were yellow perch.

*Annual totals for summer through winter.*–In the annual period from April 28 2001 through March 31, 2002, anglers fished 134,205 hours and made 51,330 trips to Burt Lake (Table 13). Of the total annual fishing effort, 64% occurred in the open-water summer period and 36% occurred during ice-cover winter period.

Yellow perch and walleyes were the most numerous species caught (harvested + released) in Burt Lake at 106,338 and 9,777, respectively. Resulting catch rates (catch per h) for yellow perch and walleyes were 0.7924 and 0.0729, respectively. A total of 895 northern pike were caught, resulting in a catch rate of 0.0067. Anglers caught 796 smallmouth bass, and 609 largemouth bass, resulting in catch rates of 0.0059 and 0.0045, respectively. 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 experience.

Twenty species that we captured during spring netting operations did not appear in the angler catch – white sucker, brown bullhead, golden redhorse, greater redhorse, yellow bullhead, bowfin, pumpkinseed, black bullhead, bluegill, black crappie, lake herring, logperch, burbot, common carp, longnose gar, muskellunge, sea lamprey, silver redhorse, brook trout, and tiger muskellunge.

The total annual harvest in Burt Lake was 68,093 fish. Yellow perch were the most commonly harvested species at 59,061, followed by walleyes at 8,004. The majority of perch were harvested in the fall and winter months, while walleyes were harvested more evenly throughout the year (Table 13). The remainder of the annual harvest comprised mostly rainbow trout, brown trout, smallmouth bass, northern pike, and rock bass. There was minimal harvest of largemouth bass and white bass.

Anglers reported releasing 44% of all yellow perch caught, 18% of walleyes, 67% of northern pike, 86% of smallmouth bass, and 99% of largemouth bass, 7% of rainbow trout, and no brown trout. Although we did not differentiate between sub-legal and legal released fish, we assume that a large proportion of the walleyes and northern pike released were sub-legal.

We did not survey from October 1 through December 31, because we thought that relatively little fishing occurred during that time of year. However, 30 walleye tag returns (19% of total annual returns), and 1 northern pike tag return (20% of total) were reported as caught during this time (Table 10). Thus, it appears that we may have missed some angler effort, and consequently have underestimated the total annual walleye and pike harvests from Burt Lake. Total annual walleye harvest from Burt Lake was actually about 19% higher than our direct survey estimate, or 9,495 walleyes. Total annual northern pike harvest from Burt Lake was about 20% higher than our direct survey estimate, or 355 northern pike. April was not surveyed because both walleye and northern pike seasons are closed at that time.

## Discussion

### *Fish Community*

Because of the seasonal bias, we likely caught more large, mature fish of several species than would normally be caught in surveys that have historically been conducted later in spring or summer. This would include spring spawners such as walleyes, northern pike, white sucker, and smallmouth bass.

The seasonal and gear biases associated with our survey preclude comparisons of population and community indices to most other surveys of Michigan lakes. Because of the mesh-size bias, smaller fish would not be represented in our sample in proportion to their true abundance in the lake. This would include juveniles of all species as well as entire populations of smaller fishes known to exist in Burt Lake such as various species of shiners, darters, minnows. For example, 16 species of fish have been collected or observed in Burt Lake in previous surveys (Table 14) that were not collected in 2001 (see Appendix).

Walleyes, white sucker, and northern pike accounted for almost 69% of the total catch, compared to 44% at similar survey on adjacent Crooked and Pickerel lakes. A less intensive fish community survey was done at Burt Lake in the spring of 1995 using trap-nets (100 lifts). Fourteen species were collected during this survey, with walleye, white sucker, and northern pike comprising 93% of the catch by number.

As indicated previously, panfish were present in the survey, but were not found in great numbers with the exception of rock bass. While the low numbers of these fish in our survey may be due to the survey gear and timing, the creel survey results also suggest that panfish densities are low, with the exception of yellow perch.

The trout populations in Burt Lake are a testimony to the quality of the rivers that feed the lake. The Sturgeon and Maple river systems harbor quality spawning runs of rainbow and brown trout. The young fish, particularly rainbow trout, often migrate downstream and live out their remaining life cycle in Burt Lake. Trout have access to more forage in the lake, and can grow to impressive sizes (Table 5). The number of trout that we observed in nets may not be a good measure of their relative abundance because it is not the gear of choice for sampling trout populations.

As part of the Large Lakes Program we recently surveyed Houghton Lake (Clark et al. 2004) and Crooked and Pickerel lakes (Hanchin et al. 2005b) using methods and gears similar to this survey. Thus, it should be reasonable to compare fish community composition indices for Burt Lake to these other lakes.

The proportion of piscivores in Burt Lake was similar to that of nearby Crooked and Pickerel lakes, but the proportions of other feeding guilds were different. We observed 26% piscivores, 20% pelagic planktivores-insectivores, and 54% benthivores in Burt Lake versus 24% piscivores, 49% pelagic planktivores-insectivores, and 27% benthivores in Crooked and Pickerel lakes. One large difference between the communities is that Burt Lake has more suckers, perhaps due to the quantity of tributaries flowing into Burt Lake, and their large size.

The fish community of Burt Lake however, was vastly different from that of Houghton Lake, which had 61% piscivores, 30% pelagic planktivores-insectivores, and 9% benthivores. The differences in fish community composition are in part a result of differences in lake morphologies and habitats. For example, maximum depths in Burt Lake and Crooked and Pickerel lakes are 73 ft and 75 ft, respectively, whereas the maximum depth of Houghton Lake is only 22 ft. Also, a much greater proportion of the water volumes in Burt Lake and Crooked and Pickerel lakes are deeper than 20 ft (about 90% and 55%, respectively) compared to Houghton Lake (<0.1%). These depth-volume characteristics probably favor production of a greater proportion of pelagic species in Burt, Crooked, and Pickerel lakes.

### *Walleyes and Northern Pike*

*Size structure.*–The size structures of both walleyes and northern pike in our spring survey were average. Based on the length-frequency distributions alone, the growth potential of walleyes and northern pike in Burt Lake appears normal for an oligotrophic-mesotrophic large lake. Walleyes are unlikely to attain lengths greater than 25 in, and northern pike rarely reach lengths greater than 35 in. We discuss possible reasons for, and ramifications of this scenario in the '*Mean lengths at age*' section.

*Sex composition.*–Male walleyes outnumbered females in our survey for fish of legal size and for all fish. This is consistent with past spring spawning surveys of walleyes in Burt Lake. The sex composition of walleyes from 1970 to 1991 in surveys of Burt Lake was on average 88% males and 12% females, with an average of 1,010 fish examined.

Sex of walleyes is readily determined during the spawning season by extruding gametes, but at other times of the year sex determination would require dissection of the fish, which is not part of past sampling protocols.

For walleyes from other lakes in Michigan and elsewhere, males consistently dominate sex composition in samples taken during spawning (Clark et al. 2004). This is likely due to males maturing at earlier sizes and ages than females and to males having a longer presence on spawning grounds than females (Carlander 1997).

Male and female northern pike were collected about equally in Burt Lake when all sizes were considered. When only legal size fish were considered, females outnumbered males. This disparity between sex composition of all northern pike and those of legal size is likely due to faster growth in females. Higher natural mortality of males as reported by Craig (1996) would also contribute to this disparity, but our mortality rates for males and females were not significant. Clark et al. (2004) and Hanchin et al. (2005a) found the same disparity in sex ratio of all northern pike versus northern pike of legal size in other Michigan lakes.

For northern pike from other lakes, males dominate sex composition in spawning-season samples, but not at other times of the year (Priegel and Krohn 1975; Bregazzi and Kennedy 1980). Bregazzi and Kennedy (1980) sampled northern pike with gill nets set throughout the year in Slapton Ley, a eutrophic lake in southern England. Sex ratios during the February and March spawning period ranged from 6:1 to 8:1 (male to female), but the overall sex ratio for an entire year of sampling was not significantly different from 1:1.

*Abundance.*–We were successful in obtaining abundance estimates for walleyes in Burt Lake (Table 6). For the multiple-census estimate, we obtained the minimum number of recaptures; however, we may have violated some conditions for an unbiased estimate that are discussed later. For the single-census estimate, we did not have sufficient numbers of fish observed for marks. Assuming that the legal walleye population was approximately 30,000 fish, and based on tagging around 2,000 fish, the recommended recapture sample to observe for marks in management studies ($\alpha$ = 0.05, $p$ = 0.25; where: $p$ denotes the level of accuracy, and 1-$\alpha$ the level of precision) is approximately 1,000 fish (Robson and Regier 1964). Our corrected recapture sample of 499 fish was short of this recommendation, but it exceeded the recommendation (300 fish) for preliminary studies and management surveys ($\alpha$ = 0.05, $p$ = 0.50).

We think our single-census estimates were more reliable than our multiple-census estimates. Single-census estimates compared more favorably to other independently-derived estimates and had less serious methodological biases. The multiple-census estimates for walleyes were lower than the single-census estimates for both legal size fish and adult fish (Table 6), and there was only a slight overlap of the confidence limits between the two types of estimates for adult walleyes. Precision was similar between the single-census and the multiple-census estimates (Table 6). Confidence limits were within 35% of the single-census estimates, and within 28% of the multiple-census estimates.

Our single-census estimate appeared more accurate than the multiple-census estimate when judged in relation to the independently-derived harvest estimate. For example, our adjusted (for non-surveyed months, and fish that were sub-legal at marking) harvest estimate of 7,438 legal-size walleyes would represent an exploitation rate of 55% if our multiple-census population estimate of 13,622 legal-size walleyes was accurate (Table 6). The harvest estimate fits better with the single-census population estimate of 32,295, producing an exploitation rate of 23%.

Both our multiple-census estimate of 21,832 adult walleyes and our single-census estimate of 42,032 adult walleyes were well below the Wisconsin regression estimate of 52,012 (Table 6). Our multiple-census estimate was 58% lower, and our single-census estimate was 19% lower. Thus far in our Large Lakes Program there appears to be a lake size effect on the similarity among the three estimates. The estimates tend to be more similar for smaller water bodies.

Population density of walleyes in Burt Lake was about average compared to other lakes in Michigan and elsewhere. Our single-census estimate for legal-size walleyes in Burt Lake was 32,295 or 1.9 per acre. Lockwood (1998, unpublished data) reported a density of 0.8 legal-size walleye per acre on nearby Mullett Lake, and Hanchin et al. (2005b) reported 2.1 per acre on nearby Crooked and Pickerel lakes. Clark et al. (2004) estimated 2.9 legal walleyes per acre in Houghton Lake, Michigan, and Hanchin et al. (2005a) reported 1.5 legal walleyes per acre in Michigamme Reservoir.

A different single-census method has been used for walleyes since the mid-1980s on smaller lakes in Wisconsin, Michigan, and Minnesota (Hansen 1989; Rose et al. 2002). These authors recaptured marked fish with electrofishing gear several days after the fish were marked. Results of these estimates were used to create the Wisconsin regression equation, which predicts Burt Lake should have 52,012 spawning walleyes or 3.0 adult walleyes per acre. Population densities from our multiple-census and single-census estimates of adult walleyes were 1.3 and 2.4 per acre, respectively. Nate et al. (2000) reported an average density of 2.2 adult walleyes per acre for 131 Wisconsin lakes having natural reproduction.

We were less successful in obtaining abundance estimates for northern pike (Table 6), largely due to the small number of legal-size northern pike that were tagged. We were able to make a multiple-census estimate for legal northern pike abundance, but the upper confidence limit is high due to inconsistent marking and recaptures from day to day during the spring survey. We also did not observe any legal northern pike recaptures during the creel survey, but the single-census method (Chapman modification of the Petersen formula) allows for an estimate because 1 is added to the number of recaptures for an unbiased estimate. Using our estimate of legal-size northern pike abundance of approximately 900 fish, and knowing that we tagged approximately 60 fish, the recommended recapture sample to observe for marks in preliminary studies and management surveys ($\alpha$ = 0.05, $p$ = 0.50; where: $p$ denotes the level of accuracy, and 1-$\alpha$ the level of precision) is approximately 250 fish (Robson and Regier 1964). Our corrected recapture sample of 13 fish was well short of this recommendation. The high CV (0.68) of this estimate also corroborates the low precision, and ultimately its low reliability.

The single-census estimate of adult northern pike also was unreliable, due to its direct calculation from the estimate for legal fish. Our most reliable estimate for northern pike was the multiple-census estimate of adults. Confidence intervals for estimates of adult abundance were broad (Table 6). For example, while the single-census estimate was considerably higher than multiple-census estimate, the 95% confidence limits for the two estimates overlapped. Precision was similar for the two estimates. Upper confidence limits were within 139% of the multiple-census estimate and within 134% of the single-census estimate. Because we only had a single reliable estimate for northern pike in Burt Lake, it is not prudent to use the set of estimates for broad comparisons between methods.

Despite low confidence in our single-census estimate of legal-size pike, it appeared accurate when judged in relation to the independently-derived harvest estimate. Our corrected harvest estimate of 308 legal-size northern pike fits with an abundance estimate of 910 fish, producing a reasonable exploitation rate of 33.8%.

Population density of northern pike in Burt Lake was low compared to other lakes in Michigan and elsewhere. Craig (1996) reported densities for northern pike from across North America and Europe ranging from 1 to 29 fish per acre (considering only estimates done for age 1 and older fish). Also, Pierce et al. (1995) estimated abundance and density of northern pike in seven small (<300 ha) Minnesota lakes. Their estimates of density ranged from 4.5 to 22.3 per acre of fish age 2 and older. Our estimates of numbers of adult northern pike in Burt Lake would essentially be for fish age 2 and older, and should be comparable, but our single-census estimate converted to a density of only 0.1 per acre. Clark et al. (2004) reported an adult northern pike density of 1.6 per acre for Houghton Lake, Michigan, and Hanchin et al. (2005a) reported 2.0 for Michigamme Reservoir in Michigan. Our estimate for Burt Lake is much lower than either of these estimates which were considered low-density populations.

There are several potential sources of error in our multiple-census estimates of walleye and northern pike abundance. One assumption of the method is that marked fish become randomly mixed with unmarked fish. Over the course of our netting operation marked fish were probably not mixing completely with the total population at large. An alternative description of this condition is that fishing effort is randomly distributed over the population being sampled (Ricker 1975). As fish moved off the spawning grounds and were excluded from our sampling gear, we violated this assumption. In contrast to the problems associated with the multiple-census method, the single-census estimate from the creel survey is likely to be more accurate because it allows sufficient time for the marked fish to fully mix with unmarked fish. Additionally, it does not matter if all spawning congregations are sampled in the initial tagging operation.

Our multiple-census estimates were 48–58% lower than single-census estimates for walleyes, and 60–64% lower for northern pike. As previously mentioned, the single-census estimates for northern pike were unreliable, and were likely underestimates. Our results were similar to those of Pierce (1997) who found that multiple-census methods underestimated abundance. He compared multiple-census estimates of northern pike abundance made with a single gear type (trap nets) to single-census estimates made with two gear types (marking with trap nets and recapturing several weeks later with experimental gill nets). He found that multiple-census estimates averaged 39% lower than single-census estimates. Pierce concluded that gear size selectivity and unequal vulnerability of fish to near shore netting make multiple-census estimates consistently low. He also concluded that recapturing fish at a later time with a second gear type resulted in estimates that were more valid. Clark et al. (2004) and Hanchin et al. (2005a) also found that multiple-census methods underestimated walleye and northern pike abundance relative to single-census methods.

Clark et al. (2004) described how to improve accuracy and precision of abundance estimates on Houghton Lake by increasing either the number of fish tagged or recaptured, but noted that even marginal improvements would be very costly. Based on our experience in this study, we believe it would be possible, but costly, to improve the precision of the walleye abundance estimates for Burt Lake. Obtaining more precise estimates would require: 1) marking more fish; 2) recapturing more marked fish; or 3) both. Confidence limits on our bi-census estimate of 32,295 legal-size walleyes were ±35% of the estimate (Table 6), which is about what would be predicted from Figure 4 given 1,877 fish, or 5.8% of the population was marked. We collected and marked 1,623 walleyes with three, 10-net, 3-person work crews, and collected 254 by electrofishing. The average number of fish marked per 3-person crew was approximately 600 over the course of the 3-week survey. In order to achieve precision of ±20%, it would be necessary to mark about 9,689 walleyes (30% of the population – Figure 4). Assuming that the number of fish marked per crew did not diminish with increasing number of crews, this would have taken 16 netting crews with 48 people and over 160 nets working on the lake during the three weeks after ice-out. This amount of necessary effort would more than quintuple the effort used on the survey. Clark et al. (2004) and Hanchin et al. (2005a) estimated twofold and sixfold increases in necessary effort when doing the same exercise for improving the precision of abundance estimates on other large lakes.

Improving precision by increasing the number of fish recaptured would also be costly. Based on the formula for confidence limits, a supplemental recapture effort using nets, electrofishing gear, or additional angler survey clerks would have to obtain a threefold increase in the number of marked and unmarked fish observed in the recapture run to improve precision to about ±20%. This would require several additional angler survey clerks or a substantial netting and/or electrofishing effort, which would be cost prohibitive.

*Mean lengths at age.*–Mean lengths at age for walleyes from our survey were similar to those from previous surveys of Burt Lake (Table 15). In the past, the mean growth index for walleyes in Burt Lake has been within the bounds of ±1.0 in (MDNR Fisheries Division, unpublished data; Table 15). Schneider (2000) suggests that growth indices in the range of ±1.0 in are satisfactory for game fish, so recent walleye growth in Burt Lake has been satisfactory.

Walleye mean lengths at each age in 2001 were slightly lower than the state average for most ages (Tables 7 and 15). However, this may be attributable to differences in aging techniques as explained earlier, and thus should be interpreted with caution. Walleyes appeared to grow significantly better in Burt Lake than in nearby Crooked and Pickerel lakes (Hanchin et al. 2005b). The typical walleye in Burt Lake reaches legal size by age 4 (Table 7) compared to age 5 or 6 in nearby Crooked and Pickerel lakes.

The values we calculated for $L_\infty$ provide us some insight into the growth potential of individuals in a population. The $L_\infty$ for male and female walleyes was 22.0 and 24.7 in, respectively, which indicates normal to good growth potential. For comparison, $L_\infty$'s for walleyes in neighboring Crooked and Pickerel lakes were considerably lower at 18.1 in for males, 20.7 in for females, and 18.6 in for all walleyes (Hanchin et al. 2005b). It is important to explain that the $L_\infty$ is not the actual length that an average fish attains in its lifetime, but is rather a theoretical maximum length.

Mean lengths at age for northern pike from our survey were similar to those from previous surveys of Burt Lake, when sample sizes for older surveys were adequate (Table 16). The mean growth indices were +0.3, -0.2, and -0.2 in, for 1955, 1969, and 2001, respectively (Table 16). These corresponding mean lengths at age were similar to the statewide average. Schneider (2000) suggests that growth indices in the range of ±1.0 in are satisfactory for game fish, so northern pike growth in Burt Lake has typically been satisfactory. As with walleyes, state averages for northern pike were based entirely on scale aging, which probably overestimates mean lengths for older ages. Although biases of finray aging are unknown, we consider the most recent estimates likely the best.

Length infinity ($L_\infty$) values of male (27.2 in) and female (33.0 in) northern pike suggest that growth is average for this species. Female pike typically attain legal size (24 in) between ages 4 and 5 while males attain this size later. Northern pike through age 9 were observed in the 2001 collections, indicating that these fish can survive and reproduce for some years after recruiting to legal size.

*Mortality.*–To our knowledge, this was the first attempt to estimate total mortality of walleyes from Burt Lake. Total mortality of walleyes in Burt Lake was lower than average, with at least 18 year classes represented (Table 9). Regarding longevity, the maximum age that we observed in samples was 7 years older for male walleyes, suggesting that males might be longer lived.

Compared to total mortality estimates for walleyes from other lakes in Michigan and elsewhere, our estimate of 38% is about average. Total mortality rates from other large lakes in Michigan have ranged from 37% to 51% (Clark et al. 2004, Hanchin et al. 2005a). Schneider (1978) summarized available estimates of total annual mortality for adult walleyes in Michigan. They ranged from 20% in Lake Gogebic to 65% in the bays de Noc, Lake Michigan. Schneider also presented estimates from lakes throughout Midwestern North America, other than Michigan. They ranged from 31% in Escanaba Lake, Wisconsin to 70% in Red Lakes, Minnesota. Colby et al. (1979) summarized total mortality rates for walleyes from a number of lakes across North America. They ranged from 13% to 84% for fish age 2 and older, with the majority of lakes between 35% and 65%.

Our estimate of the annual exploitation rate of walleyes was 9.0% from tag returns and 23.0% based on estimated harvest/abundance. Both estimates were in a reasonable range lower than the estimates of total mortality. The average of the two estimates was 16%. We consider the tag return estimate to be a minimum because we did not adjust for tagging mortality, or non-reporting, and if these occurred to any degree, we would have underestimated exploitation (Miranda et al. 2002). We did adjust for tag loss which resulted in a 4% increase from the unadjusted estimate. Kallemeyn (1989) reported a 27% increase in an estimate for exploitation of walleyes when adjusting for loss of Carlin tags. We did not estimate tagging mortality, and did not make a true estimate of non-reporting. Still, all tags observed by the creel clerk were subsequently reported by anglers.

We attempted to measure non-reporting of tags by offering a $10 reward on about half of the tags and comparing return rates of reward to non-reward tags. We found that reporting rate was similar between reward and non-reward tags in Burt Lake. 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 non-reward tags. Our reward amount was relatively low compared to those used by other authors (Miranda et al. 2002).

The MDNR previously estimated walleye exploitation in Burt Lake from tag returns in 1975, 1980, and 1995. They had respective return rates of 17.9%, 16.1%, and 4.6%. Our estimate of angler exploitation was lower than the average of previous estimates; however it does not necessarily represent a true decrease. Perhaps the exploitation of walleyes has decreased while the yellow perch fishery has become more popular.

Compared to exploitation rates for walleyes from other lakes in Michigan and elsewhere, our mean estimate of 16% (range = 9% to 23%) for Burt Lake is low to average. For example, Thomas and Haas (2000) estimated angler exploitation rates from western Lake Erie at 7.5% to 38.8% from 1989 through 1998. Serns and Kempinger (1981) reported average exploitation rates of 24.6% and 27.3% for male and female walleyes respectively in Escanaba Lake, WI during 1958–1979. 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.

This was the first attempt to estimate total mortality of northern pike from Burt Lake. Compared to total annual mortality estimates for northern pike from other lakes in Michigan and elsewhere, our estimate of 36% was low to average. Estimates from three other large lakes in Michigan ranged from 51% to 63% (Clark et al. 2004; Hanchin et al. 2005a). Diana (1983) estimated total annual mortality for two other lakes in Michigan, Murray Lake at 24.4% and Lac Vieux Desert at 36.2%. Pierce et al. (1995) estimated total mortality for northern pike in seven small (< 300 acres) lakes in Minnesota to be 36% to 65%. They also summarized total mortality for adult northern pike from a number of lakes across North America and they 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%.

There were 8 age classes of northern pike represented in our sample from Burt Lake (Table 9). The age structure does not indicate any severe mortality associated with attainment of legal size. Instead, the decline is gradual suggesting that both recruitment and mortality are rather consistent.

Although we are not confident in our exploitation estimate for northern pike, it is likely that angler exploitation for the system is relatively low. Our confidence in this estimate is low due to marking few fish, observing no tagged fish in the creel survey, and the low harvest of northern pike in general (Table 13). The average of our two estimates of annual exploitation for northern pike was 21%. Based on this average, and our estimate of total mortality, it appears that fishing mortality contributes only slightly more to total mortality than natural sources in Burt Lake.

Compared to exploitation rates for northern pike from other lakes in Michigan and elsewhere, our mean estimate of 21% (range = 8% to 34%) for Burt Lake is average. 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. Carlander (1969) gave a range of 14% to 41% for a sample of lakes throughout North America. Houghton Lake and Michigamme Reservoir, two other large lakes surveyed in Michigan as part of this program, had mean estimates of 20% and 31%, respectively (Clark et al. 2004; Hanchin et al. 2005a).

*Recruitment.*–We collected walleyes from 19 year classes in Burt Lake (ages 1 through 18, and 20). Year-class strength was rather consistent from 1983 through 1997, the years included in our catch-curve regression. While we did not examine recruitment indices in our study to gauge whether walleye year-class strength has been high, the data suggest that it is at least consistent in Burt Lake.

A goal of a 1993 creel survey of Burt Lake was to evaluate the walleyes stocked in 1989 and 1990 (Table 1). In cooperation with the Northern Michigan Walleye Association walleyes stocked from 1989 to 1993 were marked with a fin clip. Lockwood (MDNR, personal communication) reported that the estimated proportion (with 2 standard errors) of planted walleyes in the Burt Lake harvest was 0.29% (0.39%). Managers concluded that stocking was not contributing enough to the fishery to justify its continuation. It was terminated after 1993.

For northern pike, 8 year classes (ages 2 through 9 were represented in our samples. Year-class strength was relatively consistent from 1992 through 1997, the years included in our catch-curve regression. While there are no recruitment indices for northern pike to gauge year-class strength, we can at least assume that it is consistent in Burt Lake.

*Movement.*–The movement patterns that we observed following the spring tagging confirm that walleyes move freely throughout the inland waterway. We noted movement from Burt Lake to Crooked and Mullett lakes. Hanchin et al. (2005b) also noted walleye movement within the inland waterway, between Crooked and Pickerel lakes. Previous walleye tagging studies on Burt Lake (MDNR, unpublished data) also found movement throughout the inland waterway.

Although we documented movement of walleyes out of Burt Lake, we do not necessarily know the timing and duration of movement. While it is interesting to know the seasonal movement patterns of walleyes, movements associated with spawning are the most important. Our study did not allow us to determine if walleyes in Burt Lake demonstrate site fidelity in spawning. Knowledge of site fidelity would have potential implications in the allocation of walleye harvest, and thus should be considered in future surveys. Future efforts should involve extensive collection of spawning walleyes in the years after marking.

### *Angler Survey*

The fishery of Burt Lake is dominated by perch and walleyes. These two species comprised over 97% of the total annual catch, and are caught throughout the year. Harvest of yellow perch increased monthly from spring to fall, decreased at first ice, but then increased again throughout the winter. The catch rate of yellow perch mirrors this trend well. It was interesting that yellow perch were only reported as being released during the winter fishery. We hypothesize that smaller fish are caught more readily during the winter, resulting in angler culling of catch, and therefore released fish. Walleye harvest showed peaks in the spring, fall, and early winter, corresponding with catch rates. Catch rate for walleyes was highest in September (0.166/h), followed by April/May (0.095/h), and January (0.091/h).

The secondary species of the fishery provide significant angling opportunity, but were more seasonal in nature. Rainbow trout, for example, are caught primarily in the spring and summer, while brown trout were caught in the winter and early spring. Black bass were caught mainly in the spring and summer. Apparently, anglers on Burt Lake enjoyed a winter catch and release opportunity for largemouth bass that occasionally occurs on early ice. An estimated 585 largemouth bass were reported released during January. Northern pike were taken throughout the year in relatively low numbers.

Although we observed several panfish species in low relative abundance during the spring netting, these species are not abundant enough to provide a significant fishery. Fishing for panfish in Burt Lake is restricted primarily to yellow perch and low numbers of rock bass.

*Historical comparisons.*–A general creel census from the 1920's through the 1960's included Burt Lake, but this "census" was designed only to measure success of anglers who were actually interviewed and was not expanded to estimate total catch of all anglers. These general census estimates would not be directly comparable to our estimates. However, considering the general census alone, yellow perch and walleyes dominated the catch on Burt Lake, much as they do today. Other species reported from these general creel surveys were also observed in our survey, except for lake herring. Laarman (1976) noted that a large winter fishery for lake herring in the early 1960's had virtually disappeared as the population declined.

Two significant angler surveys have been completed in the past on Burt Lake. Ryckman and Lockwood (1985) reported results from a 1977 creel survey of Burt Lake, and Lockwood (2000a) reported results from a 1993 creel survey of Burt Lake. Methods used and time frames were similar to those used in our survey, thus results are comparable. Ryckman and Lockwood surveyed from May through September, but catch rates were only estimated for September due to the absence of counts. Lockwood surveyed from April 24 to September 11, which would be roughly comparable to our summer survey. Total angler hours and trips (with 2 standard errors) were 45,514 (5,396) and 11,339 (1,487) in 1977, 134,957 (13,073) and 33,923 (3,266) in 1993, and 85,570 (7,619) and 39,465 (3,704) in 2001. It appears that angler effort was significantly higher in 1993 than in 1977 or 2001 (Figure 11), but a multitude of factors affecting angler effort (i.e., weather conditions, fishing success, etc.) make interpretation difficult. Apparently anglers took more trips of shorter duration in 2001. Harvest of walleyes was highest in the summer of 1993, but 1977 and 2001 were comparable (Figure 12). Anglers harvested an estimated 3,869 (721) walleyes in the summer of 1977 (not including September), 17,186 (2,670) in 1993, and 5,594 (1,056) in the summer of 2001; thus, the higher effort in 1993 may have been due to better success. Accordingly, the summer harvest rate for walleyes in 1993 was twice that of in 2001 (0.1273 versus 0.0654), and also higher than the rate of 0.0850 per h in 1977 (Figure 13). Additionally, 83% of anglers in 1993 reported that they were seeking walleyes. In our 2001 survey, 53% of summer anglers and 22% of winter anglers reported that they were seeking walleyes.

Contrary to walleyes, the summer harvest of yellow perch in Burt Lake was much higher in 2001; 433 (335) in 1993 compared to 22,243 (7,905) in 2001. Accordingly, the summer harvest rate of yellow perch was 0.0032 (0.0025) in 1993, and 0.2599 (0.0952) in 2001 (Figure 13). Similar to what we saw for walleyes, the harvest of smallmouth bass was much less in 2001, with 1,317 taken in 1993, and 114 in 2001. In 2001, substantially more smallmouth bass were released (682) than were harvested. While the 1993 survey did not report on released fish, it is possible that the harvest rate of smallmouth bass is down simply due to anglers releasing more fish. The harvest of other species was similar between surveys with the exception of lake trout, of which 17 were estimated to have been harvested in 1993. While it is not prudent to draw conclusions about populations simply from harvest data, it appears that the walleye fishery may have declined since 1993, with a concurrent rise in the fishery for yellow perch (Figure 13).

*Comparison to other large lakes.*–In general, surveys conducted in Michigan in the past 10 years used the same methods we used on Burt Lake, but most of them still differ from our survey in seasonal time frame. For example, few other surveys were done in consecutive summer and winter periods. Regardless, for comparison, we used recent angler survey results for Michigan's large inland lakes from 1993 through 1999 as compiled by Lockwood (2000a) and results for Michigan's Great Lakes waters in 2001 compiled by Rakoczy and Wesander-Russell (2002).

We estimated 134,205 angler hours occurred on Burt Lake during the year from April 28, 2001 through March 31, 2002. The number of hours fished per acre was similar to Lake Gogebic, and Michigamme Reservoir, and was higher than nearby Mullett Lake (Table 17). However, the effort per surface acre was much lower than nearby Crooked and Pickerel lakes, and Fletcher Pond.

For walleyes, our adjusted (for non-surveyed months) estimated annual harvest from Burt Lake was 0.5 fish per acre. This harvest is below average relative to other waters in Michigan. The average harvest of six other large Michigan lakes (> 1,000 acres) reported by Lockwood (2000a) was 0.9 walleyes per acre, ranging from 0.1 per acre in Brevoort Lake, Mackinac County to 2.4 per acre in

Chicagon Lake, Iron County. These Michigan lakes all were subject to similar gears and fishing regulations, including a 15-in minimum size limit.

For northern pike, our estimated annual harvest from Burt Lake was 0.02 fish per acre. This harvest was well below average compared to other waters in Michigan and elsewhere. The average harvest of seven other large Michigan lakes (> 1,000 acres) reported by Lockwood (2000a) was 0.2 northern pike per acre, ranging from < 0.1 per acre in Bond Falls Flowage, Gogebic County to 0.7 per acre in Fletcher Pond, Alpena County. These Michigan lakes all were subject to similar gears and fishing regulations, including a 24-in minimum size limit. 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 limits for northern pike.

The total catch of smallmouth bass was surprisingly low. By comparison total annual catch (harvest + release) of smallmouth bass on nearby Crooked and Pickerel lakes was 1,300 (Hanchin et al 2005b) compared to 796 on the much larger Burt Lake.

The estimated annual harvest per acre of yellow perch was 3.4 for Burt Lake. In comparison, harvest per acre of yellow perch was 2.5 in Houghton Lake (Clark et al 2004), and 1.8 in Crooked and Pickerel lakes (Hanchin et al 2005b). The associated harvest rate for yellow perch in Burt Lake was 0.4401 per h, compared to 0.0988 per h for Houghton Lake, and 0.1129 per h for Crooked and Pickerel lakes.

## Management Implications

The current walleye fishery in Burt Lake should be characterized as one with consistent natural reproduction, average density, acceptable growth, low total mortality, and average angler harvest. Walleyes up to age 15 were well represented in our sample, with a few fish up to age 20. This indicated average to above-average natural reproduction. The population density was 2.4 adult walleyes per acre, and 1.9 legal-size walleyes per acre. The annual harvest was 0.5 walleyes per acre and harvest per h was 0.0596. The annual exploitation rate was 9% to 23%, and the total annual mortality was 38%. Compared to other walleye fisheries in Michigan and elsewhere, these estimates were average.

The current walleye density is probably lower than it has been in the past, but this is likely a natural fluctuation. This conclusion is supported by the catch per unit effort (number per net lift) of walleyes, which has been calculated approximately every 5 years since 1970 during spring trap-net surveys on Burt Lake. Our estimates of 5.6 per net night (7.7 per net lift) were relatively low in the time series (Figure 14).

Stocking does not appear to be necessary for the walleye population or fishery in Burt Lake. While the population could probably tolerate augmentation, potential harmful effects could result from density-dependent interactions, such as increased competition for food or cannibalism. For example, Li et al. (1996a) found that in places where walleye year-class strength was increased from stocking, the mean weight of individual fish decreased. Current walleye growth is satisfactory, which should not be compromised by introducing more fish into the system.

The northern pike fishery in Burt Lake should be characterized as one with well below average population density and harvest, low total mortality, and satisfactory growth. Natural reproduction appears consistent, but must be low level, given the low population density. Relative to other northern pike populations in Michigan and elsewhere, our estimates of legal-size population density and harvest of 0.05 and 0.02 fish per acre, respectively, were very low.

The overall fishery in Burt Lake is relatively good. The number of fish harvested per h was surpassed only by Houghton Lake and Fletcher Pond, considering large lakes surveyed under similar methods. Fish harvested per acre was also relatively high. Burt Lake has considerable angling opportunity for walleyes and yellow perch, and a high diversity of other species in lower abundance.

Methods used for harvest, abundance, age and growth, and mortality estimates for walleyes performed fairly well, considering the size of Burt Lake. Estimates for northern pike were hindered by the small number of legal-size fish collected. We are not yet able to determine which of the different methods for estimating abundance (multiple- or single-census) and fishing mortality (tag returns or harvest/abundance) are best for long-term use. Comparisons must be repeated on more lakes before conclusions can be made. Thus, the overall approach used in this study should be continued on other large lakes before significant changes are made.

Our estimates of adult walleye abundance were similar to, but lower than the estimate made a priori with the Wisconsin regression equation. Thus, in the short term, it seems reasonable to apply the Wisconsin regression to estimate walleye abundance in other Michigan lakes when abundance estimates are needed for management purposes. In the long term, MDNR should continue to work towards developing an improved regression by conducting abundance estimates in other Michigan lakes.

## Acknowledgements

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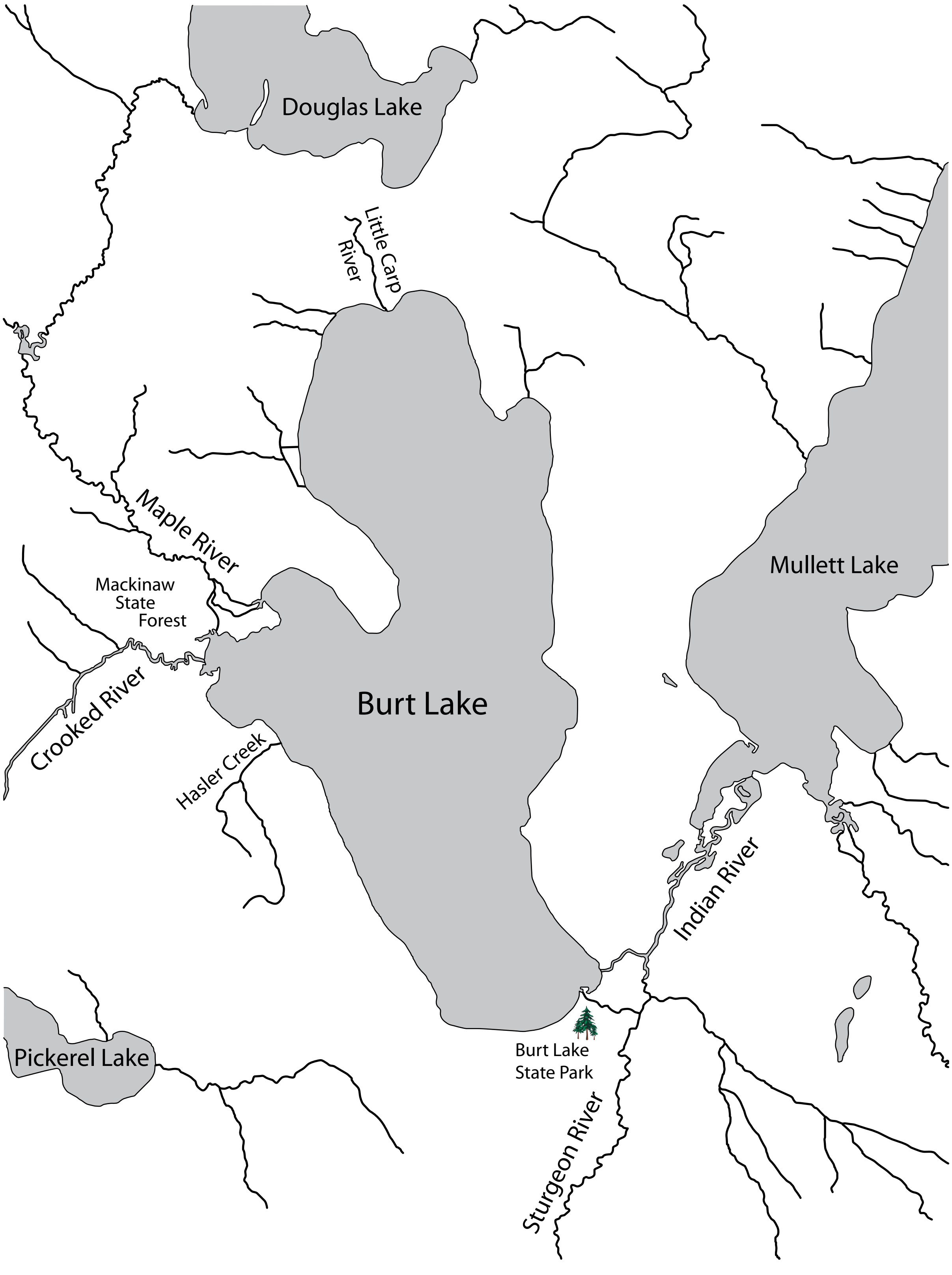



Figure 1.–Map of Burt Lake, Cheboygan County, Michigan.

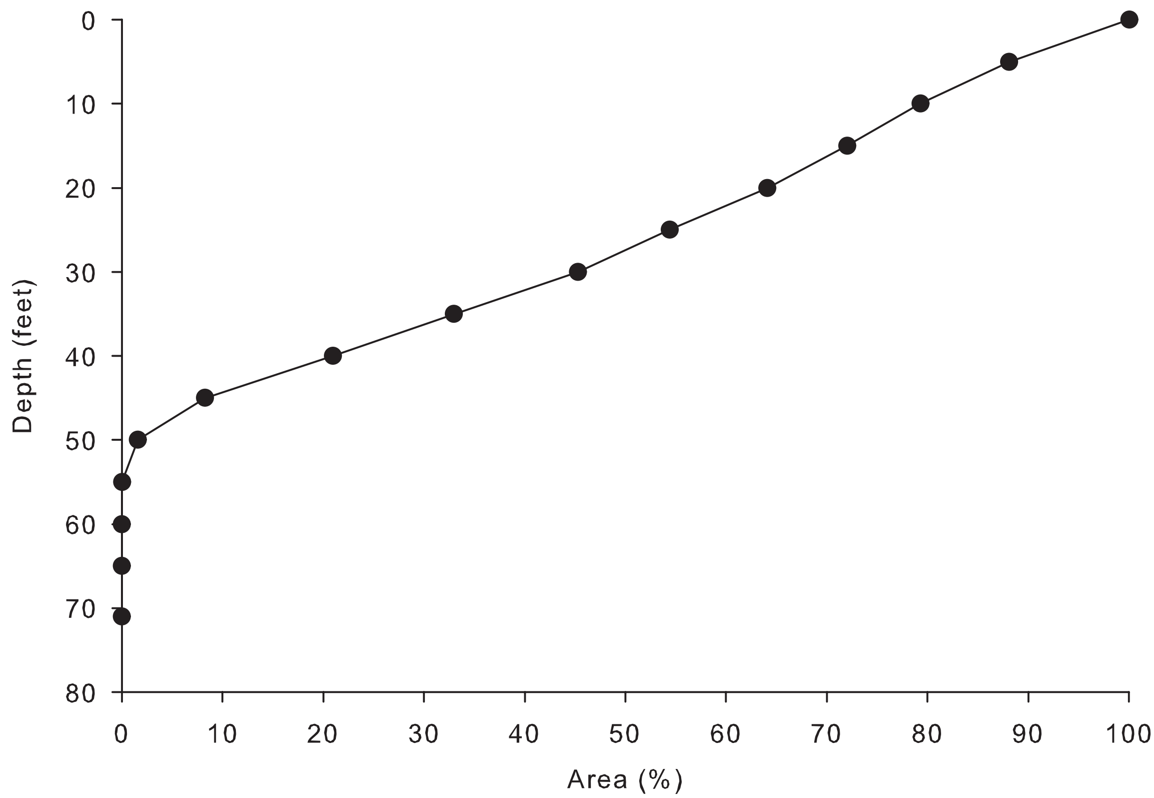



Figure 2.–Percent of area by depth for Burt Lake, Michigan. Data from Michigan Digital Water Atlas. This is a statewide program conducted by MDNR, Fisheries Division, Lansing, to develop computerized maps and reference data for aquatic systems in Michigan, available at http://ifrgis.snre.umich.edu/dwa/introduction.html.

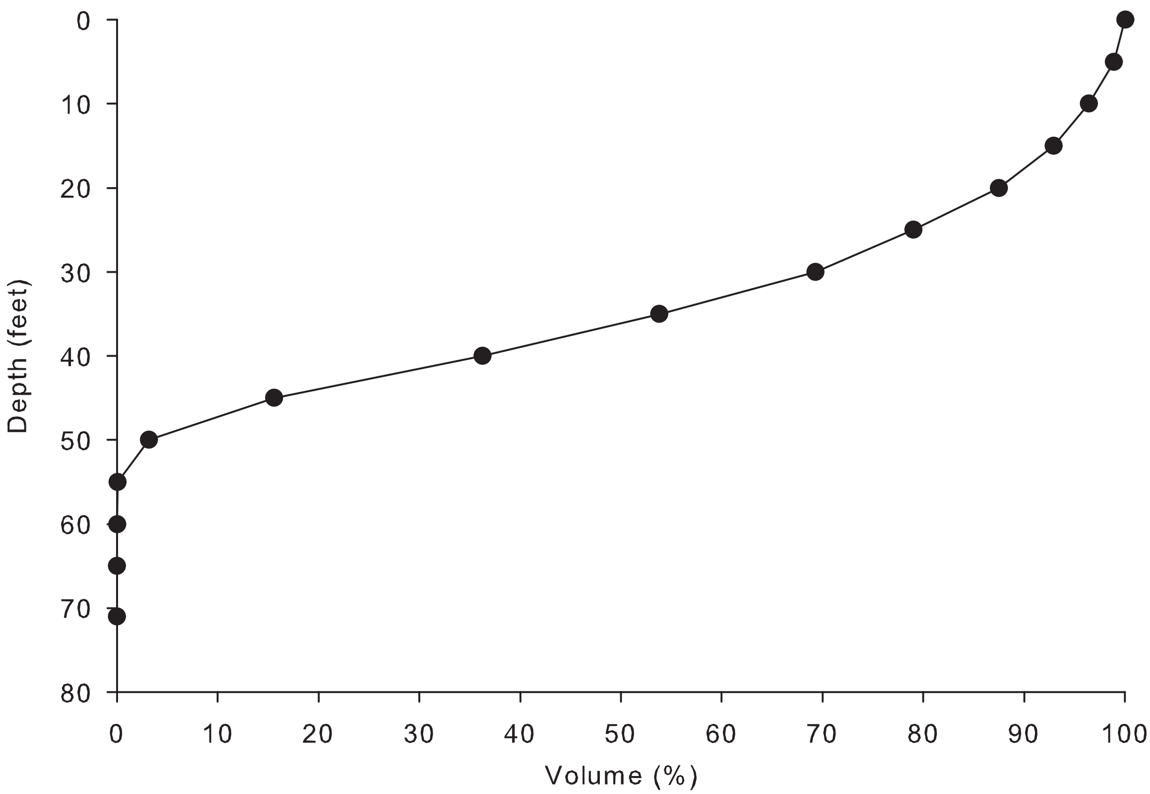



Figure 3.–Percent of volume by depth for Burt Lake, Michigan. Data from MDNR Digital Water Atlas. This is a statewide program conducted by MDNR, Fisheries Division, Lansing, to develop computerized maps and reference data for aquatic systems in Michigan, available at http://ifrgis.snre.umich.edu/dwa/introduction.html.

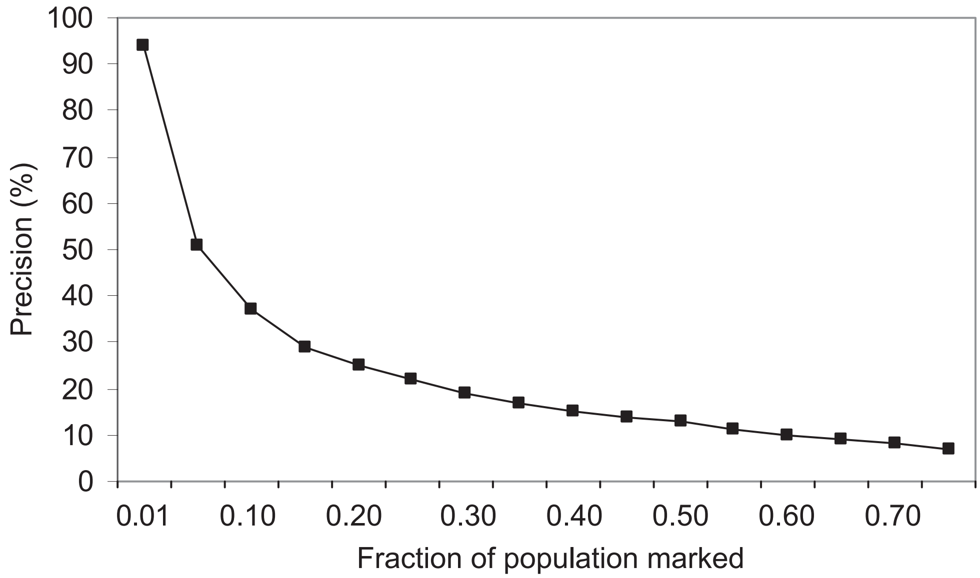
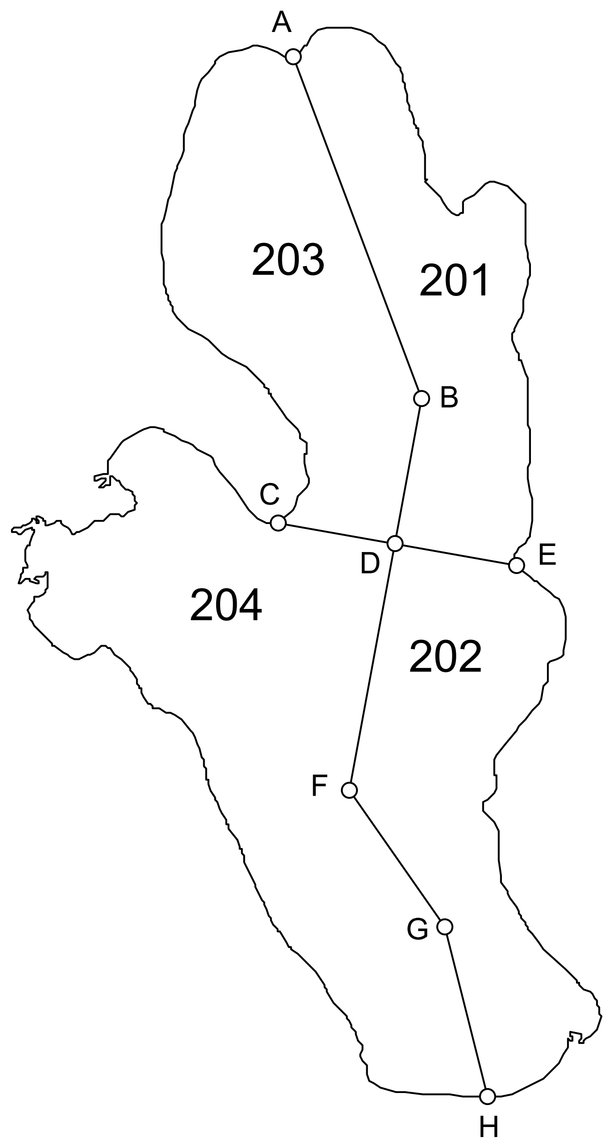



Figure 4.–Precision of walleye population estimate based on fraction of the population marked. Precision is expressed as a percentage and is the quotient of 2SE of the estimate with a given number marked and estimated population.




| Marker | Latitude | Longitude |
|---|---|---|
| A | 45° 32.19' N | 84° 40.55' W |
| B | 45° 28.90' N | 84° 39.20' W |
| C | 45° 28.51' N | 84° 40.83' W |
| D | 45° 28.31' N | 84° 39.47' W |
| E | 45° 28.20' N | 84° 37.17' W |
| F | 45° 27.07' N | 84° 40.04' W |
| G | 45° 25.43' N | 84° 39.55' W |
| H | 45° 23.97' N | 84° 38.26' W |

Figure 5.–Burt Lake count and interview grids (201-204) used during summer 2001 angler survey. Markers indicate grid boundary line points.

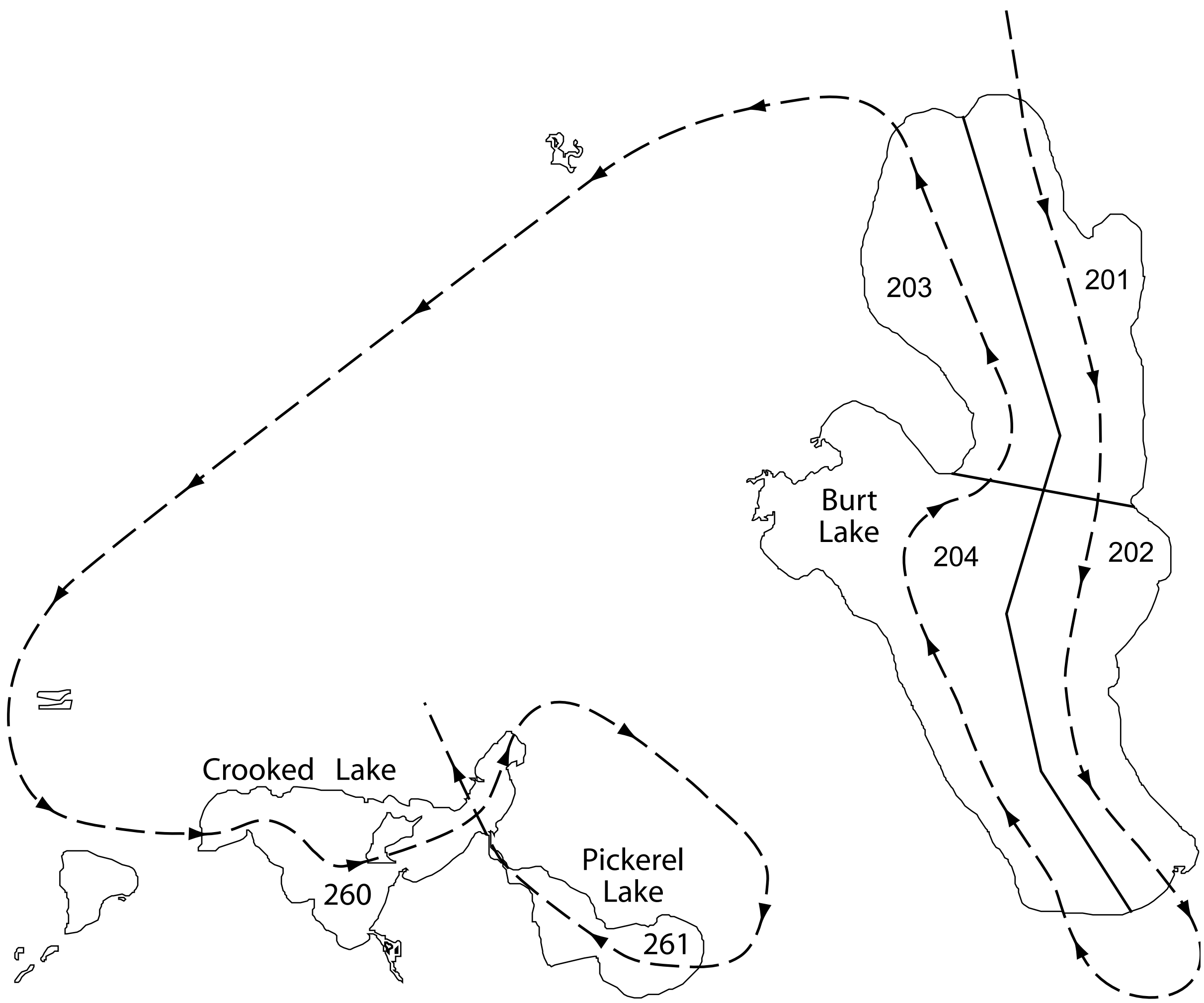



Figure 6.–Burt, Pickerel, and Crooked lakes count path used during summer 2001 angler survey. Count begins in Burt Lake grid 201 and ends at Pickerel Lake (grid 261).

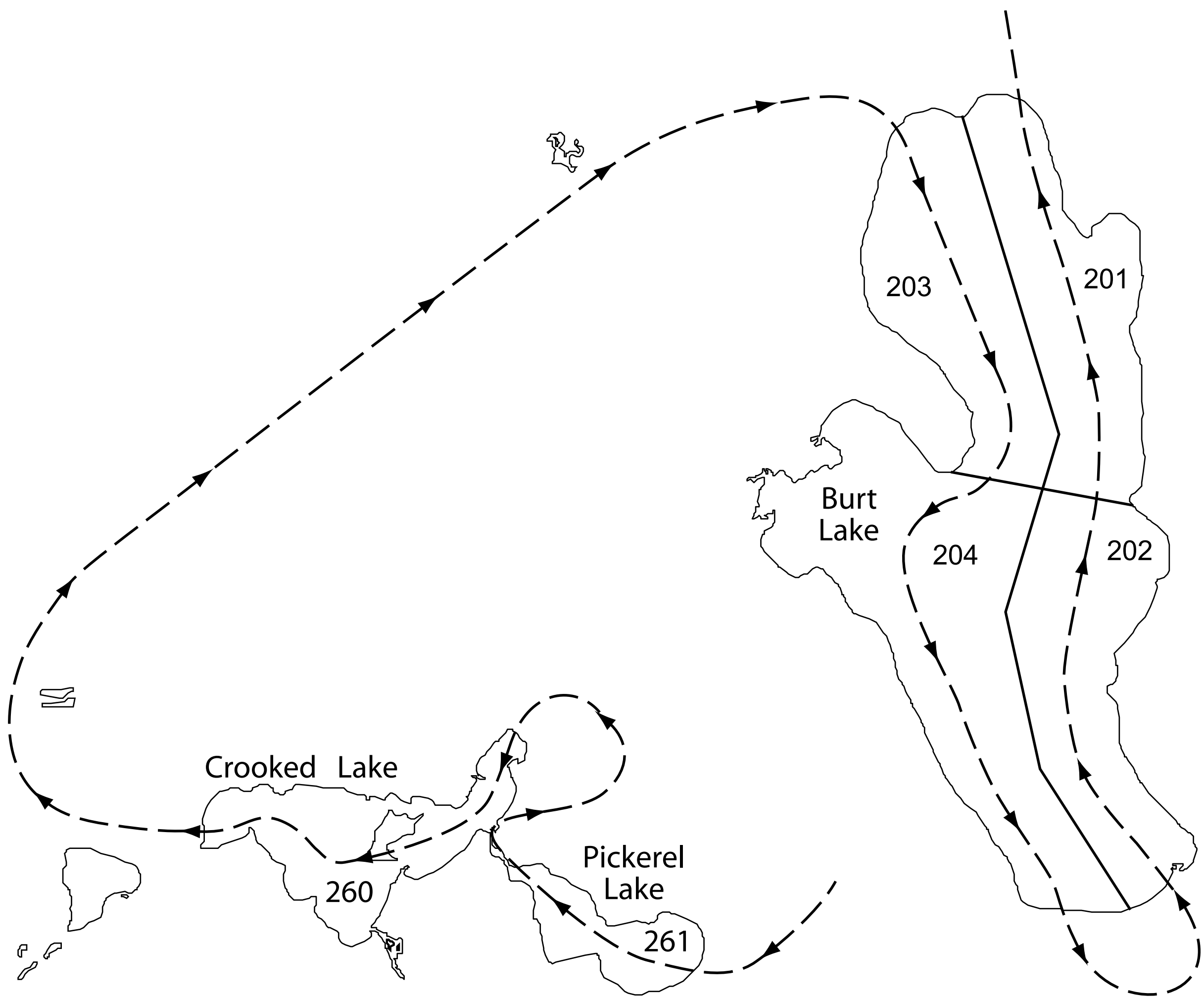
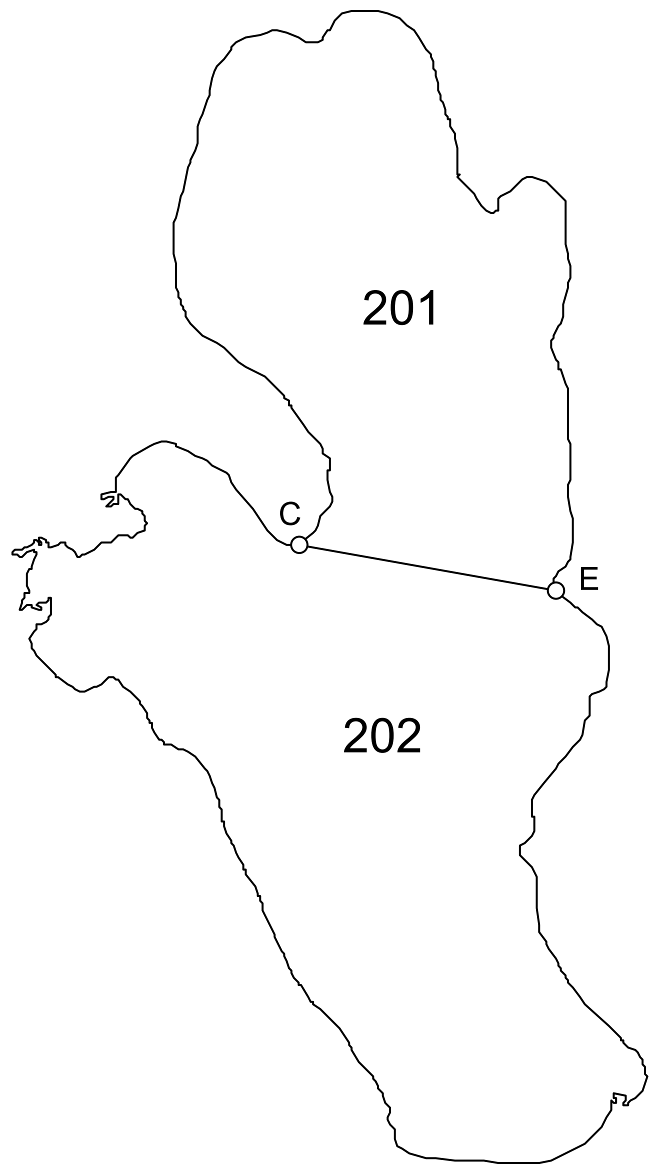



Figure 7.–Burt, Pickerel, and Crooked lakes count path ii used during summer 2001 angler survey. Count begins in Pickerel Lake (grid 261) and ends at Burt Lake grid 201.




| Marker | Latitude | Longitude |
| --- | --- | --- |
| C | 45° 28.51' N | 84° 40.83' W |
| E | 45° 28.20' N | 84° 37.17' W |

Figure 8.–Burt Lake count and interview grids used during winter 2001 and winter 2002 angler surveys. Markers indicate grid boundary line points.

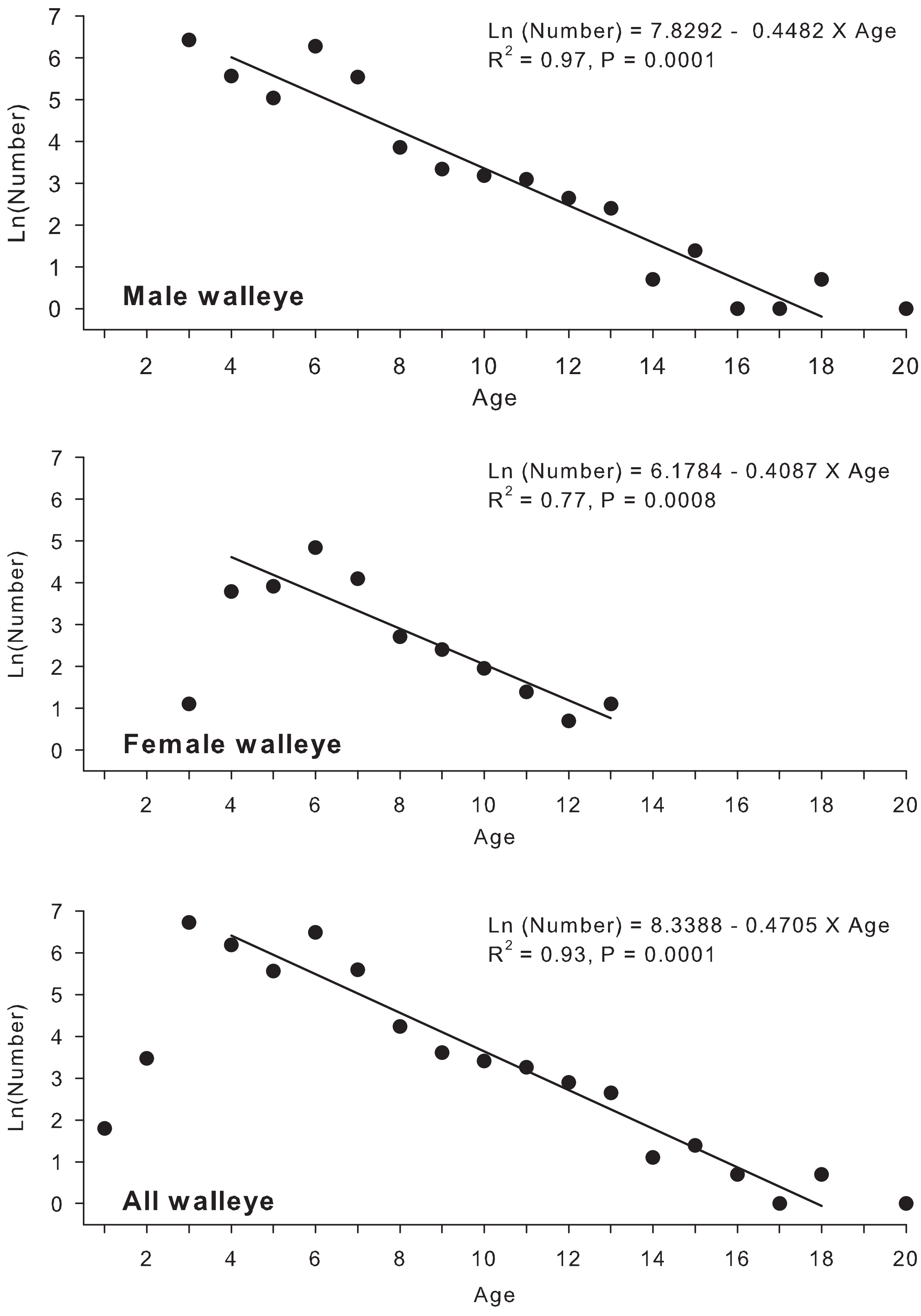



Figure 9.–Plots of observed ln(number) versus age for male, female, and all (including males, females, and unknown sex) walleye in Burt Lake. Lines are plots of regression equations given beside each graph.

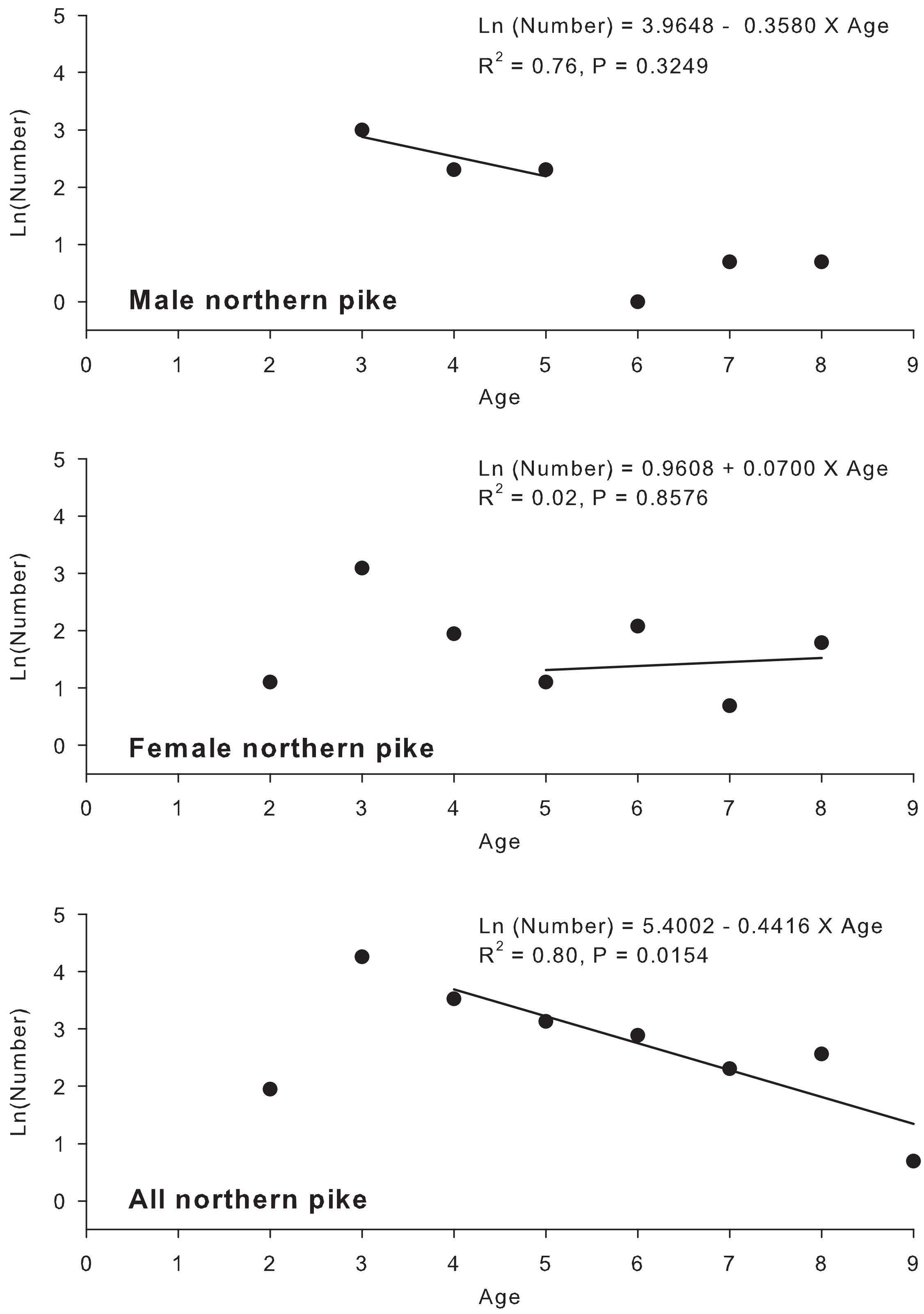



Figure 10.–Plots of observed ln(number) versus age for male, female, and all (including males, females, and unknown sex) northern pike from Burt Lake, Cheboygan County, MI. Lines are plots of regression equations given beside each graph.

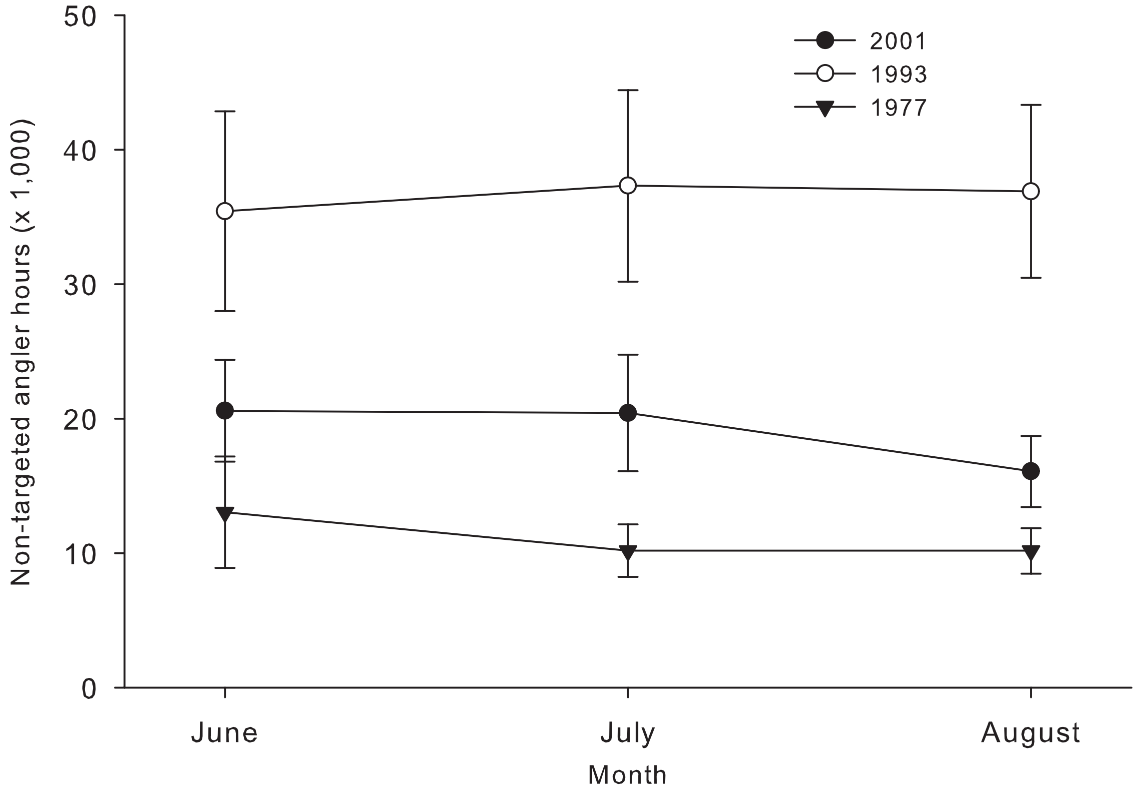



Figure 11.–Non-targeted angler hours for the months of June, July, and August for three angler surveys on Burt Lake. Vertical bars represent two standard errors.

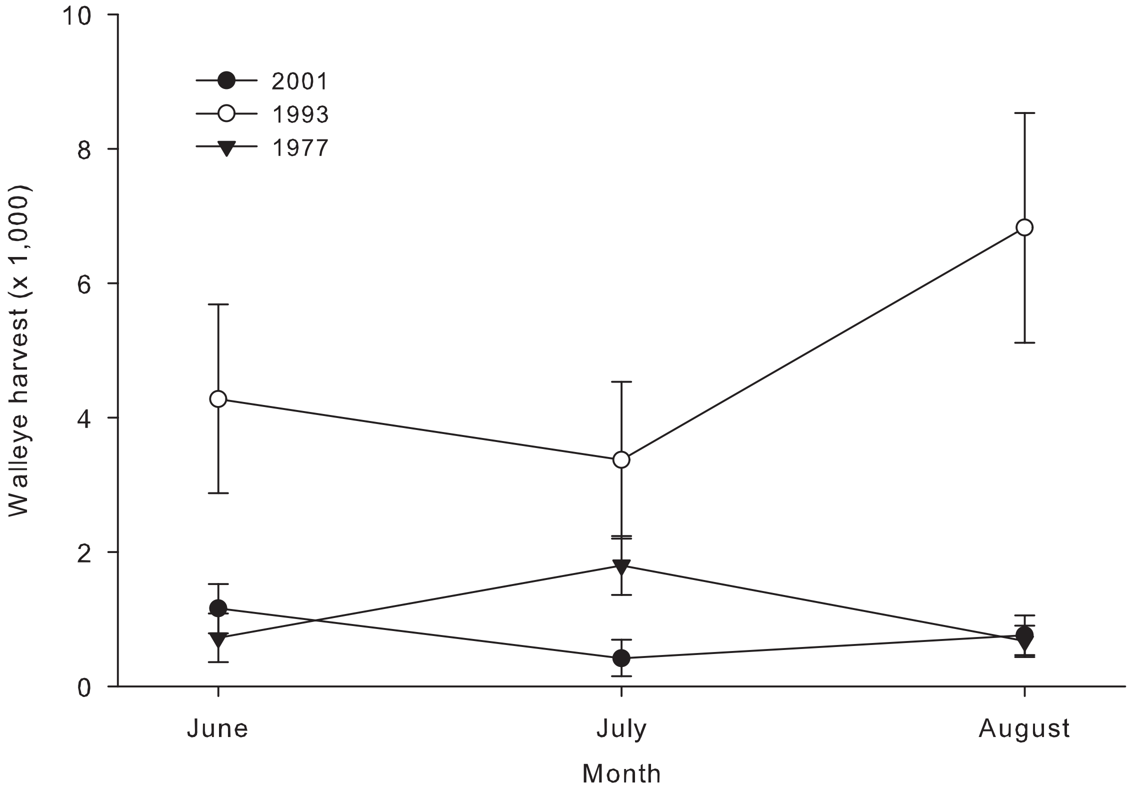



Figure 12.–Number of walleyes harvested during the months of June, July, and August for three angler surveys on Burt Lake. Vertical bars represent two standard errors.

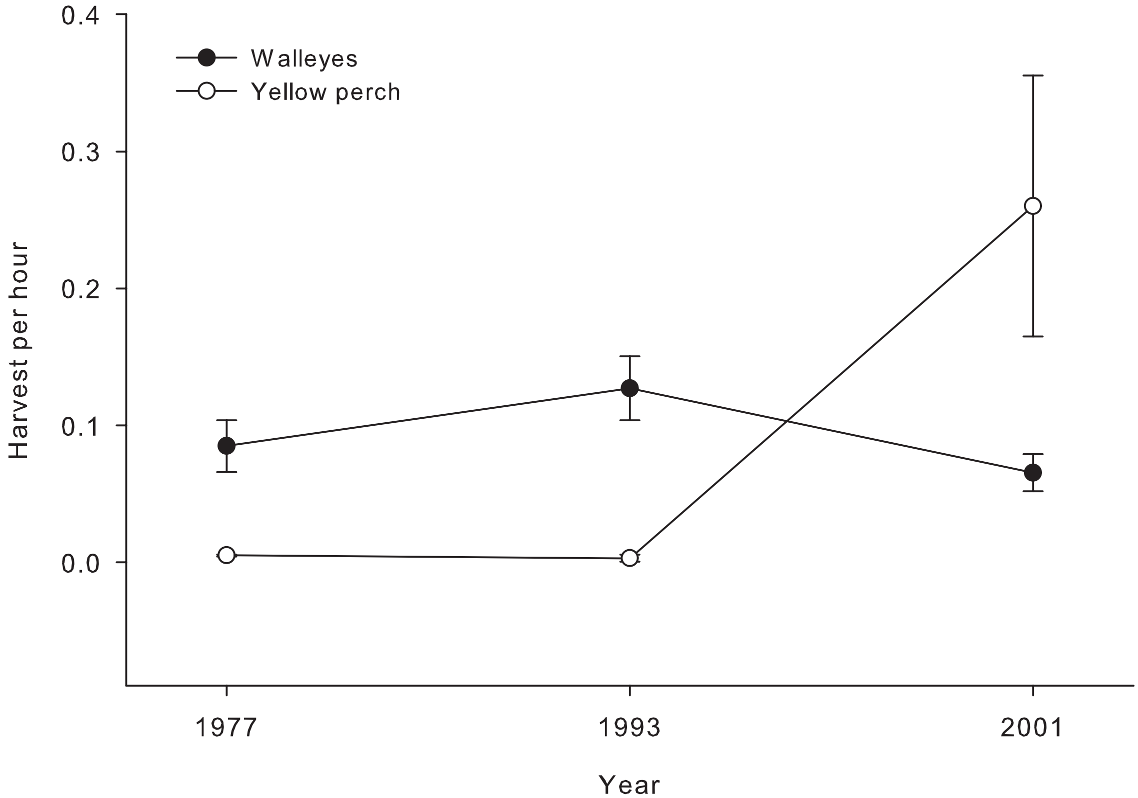



Figure 13.–Harvest per hour for walleyes and yellow perch from three angler surveys of Burt Lake. Vertical bars represent two standard errors. Error bars for yellow perch in 1977 and 1993 are smaller than symbol.

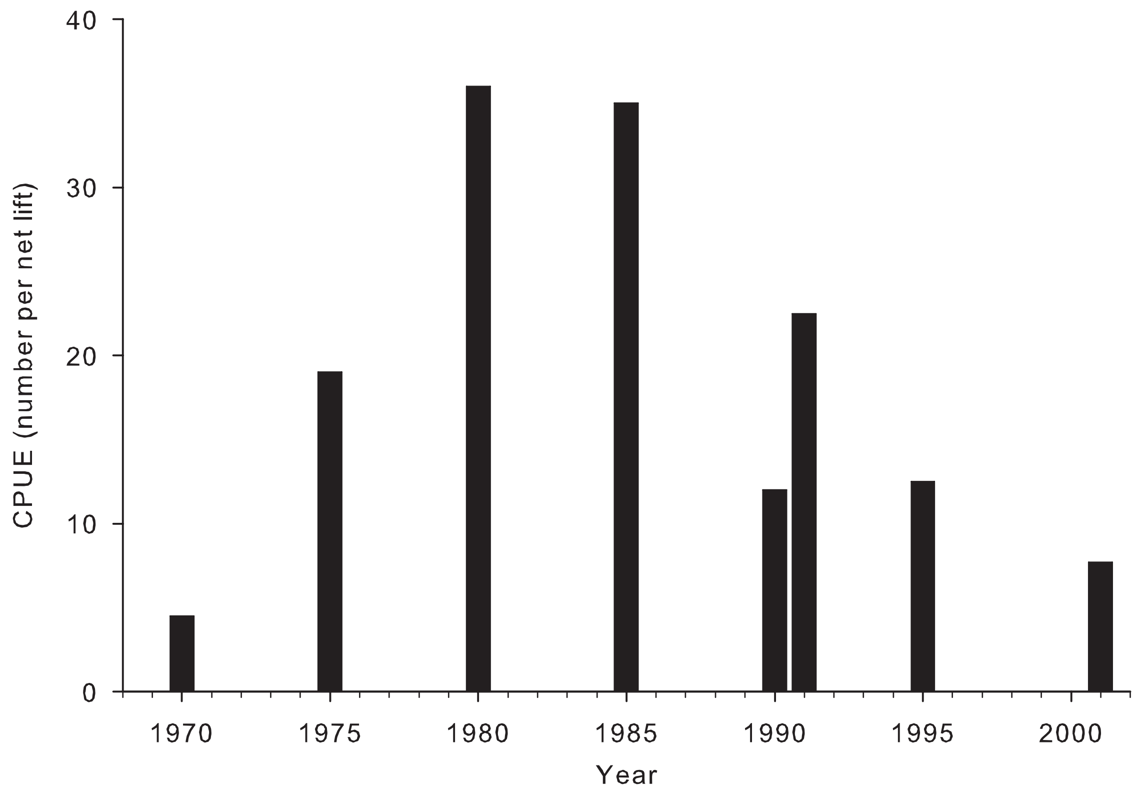



Figure 14.–Catch per unit effort (CPUE; number per trap-net lift) of walleyes collected in spring surveys on Burt Lake from 1970 to 2001.

Table 1.–Number and size of walleye fingerlings stocked into Burt Lake from 1989 through 1993. Mean length is the weighted mean length of lots planted for year.

| Year | Number stocked | Mean length (in) |
|---|---|---|
| 1989 | 20,350 | 3.5 |
| 1990 | 18,346 | 4.6 |
| 1991 | 17,000 | 4.6 |
| 1992 | 17,000 | 3.6 |
| 1993 | 16,280 | 3.6 |

Table 2.–Number of Master Angler awards for Burt Lake from 1990 through 2001.

| Year | Species | Number |
|---|---|---|
| 1990 | black crappie | 1 |
| | rock bass | 2 |
| | smallmouth bass | 1 |
| 1991 | black crappie | 1 |
| | rock bass | 5 |
| | smallmouth bass | 1 |
| 1992 | rock bass | 6 |
| 1993 | muskellunge | 1 |
| | rock bass | 5 |
| 1994 | bluegill | 1 |
| | rock bass | 4 |
| | smallmouth bass | 1 |
| | white bass | 1 |
| | white sucker | 1 |
| 1995 | rock bass | 4 |
| | smallmouth bass | 2 |
| 1996 | bluegill | 1 |
| | rock bass | 1 |
| 1997 | muskellunge | 1 |
| | rock bass | 4 |
| | smallmouth bass | 1 |
| | yellow perch | 1 |
| 1998 | rock bass | 2 |
| | smallmouth bass | 1 |
| 1999 | muskellunge | 1 |
| | rock bass | 3 |
| | smallmouth bass | 2 |
| 2000 | muskellunge | 1 |
| | rock bass | 3 |
| | smallmouth bass | 3 |
| 2001 | muskellunge | 1 |
| | rock bass | 2 |
| | smallmouth bass | 3 |

Table 3.–Survey periods, sampling shifts, and expansion value “F” (number of fishing hours within a sample day) for Burt Lake angler survey, spring 2001 through winter 2002.

| Survey period | Sample shifts | | F |
|---|---|---|---|
| April 28 – May 31 | 0600–1430 h | 1330–2200 h | 16 |
| June | 0600–1430 h | 1330–2200 h | 18 |
| July | 0600–1430 h | 1300–2130 h | 18 |
| August | 0630–1500 h | 1230–2100 h | 17 |
| September | 0630–1500 h | 1200–2030 h | 16 |
| January 1 – March 31, 2002 | 0700–1530 h | 1100–1930 h | 13 |

Table 4.–Fish collected from Burt Lake using a total sampling effort of 321 trap-net lifts, 31 fyke-net lifts, and 6 electrofishing runs from April 19 to May 9, 2001.

| Species | Total catch[a] | Percent by number | Mean CPUE[b] | | Length (in) | | Number measured |
|---|---|---|---|---|---|---|---|
| | | | Trap net | Fyke net | Range | Average | |
| Walleyes | 2,899 | 16.8 | 5.6 | 2.5 | 6.3–29.0 | 16.5 | 2,745 |
| Northern pike | 203 | 1.2 | 0.4 | 0.1 | 9.8–38.1 | 23.9 | 178 |
| White sucker | 8,823 | 51.2 | 20.6 | 6.7 | 7.3–22.7 | 18.9 | 427 |
| Rock bass | 3,194 | 18.5 | 7.4 | 4.5 | 3.2–12.7 | 8.8 | 622 |
| Smallmouth bass | 1,383 | 8.0 | 3.1 | 4.7 | 8.4–21.8 | 16.3 | 787 |
| Brown bullhead | 207 | 1.2 | 0.5 | 0.1 | 7.3–16.8 | 12.2 | 159 |
| Golden redhorse | 179 | 1.0 | 0.4 | 0.4 | 15.9–29.5 | 24.5 | 155 |
| Yellow perch | 148 | 0.9 | 0.3 | 0.0 | 4.8–14.4 | 9.3 | 62 |
| Greater redhorse | 47 | 0.3 | 0.1 | 0.0 | 19.0–28.5 | 24.5 | 47 |
| Rainbow trout | 24 | 0.1 | <0.1 | <0.1 | 8.1–24.8 | 17.2 | 20 |
| Brown trout | 18 | 0.1 | <0.1 | 0.0 | 7.1–24.2 | 12.4 | 14 |
| Largemouth bass | 17 | 0.1 | <0.1 | <0.1 | 12.5–20.6 | 16.2 | 14 |
| Yellow bullhead | 14 | <0.1 | <0.1 | <0.1 | 6.5–11.0 | 9.0 | 13 |
| Bowfin | 13 | <0.1 | <0.1 | <0.1 | 8.0–24.5 | 18.8 | 7 |
| Pumpkinseed | 12 | <0.1 | <0.1 | <0.1 | 5.7–7.2 | 6.5 | 9 |
| Black bullhead | 7 | <0.1 | <0.1 | <0.1 | 8.3–13.9 | 10.9 | 7 |
| Bluegill | 7 | <0.1 | <0.1 | <0.1 | 5.7–6.9 | 6.4 | 4 |
| Black crappie | 5 | <0.1 | <0.1 | 0.0 | 9.1–13.7 | 11.4 | 5 |
| Lake herring | 4 | <0.1 | <0.1 | 0.0 | 12.1–14.3 | 13.3 | 4 |
| Logperch | 4 | <0.1 | <0.1 | 0.0 | 4.4–4.6 | 4.5 | 4 |
| Burbot | 3 | <0.1 | <0.1 | <0.1 | 5.9–7.8 | 6.9 | 2 |
| Common carp | 3 | <0.1 | <0.1 | 0.0 | 21.6–32.0 | 26.1 | 3 |
| Longnose gar | 3 | <0.1 | <0.1 | 0.0 | 17.5–21.3 | 19.5 | 3 |
| Muskellunge | 3 | <0.1 | 0.0 | 0.0 | 30.4–51.8 | 42.3 | 3 |
| Sea lamprey | 3 | <0.1 | <0.1 | 0.0 | 6.0–22.2 | 12.6 | 3 |
| Silver redhorse | 2 | <0.1 | <0.1 | 0.0 | 19.2–20.0 | 19.6 | 2 |
| Brook trout | 1 | <0.1 | <0.1 | 0.0 | 10.0 | 10.0 | 1 |
| Tiger muskellunge | 1 | <0.1 | 0.0 | 0.0 | 11.9 | 11.9 | 1 |

[a] Includes recaptures.
[b] Number per trap-net or fyke-net night.

Table 5.–Number of fish per inch group measured in spring netting and electrofishing operations on Burt Lake, April 19 to May 9, 2001.

| | Species | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inch group | Walleyes | Northern pike | White sucker | Rock bass | Smallmouth bass | Brown bullhead | Golden redhorse | Yellow perch | Greater redhorse | Rainbow trout | Brown trout | Largemouth bass | Yellow bullhead | Bowfin | Pumpkinseed | Black bullhead | Bluegill | Black crappie | Lake herring | Logperch | Burbot | Common carp | Longnose gar | Muskellunge | Sea lamprey | Silver redhorse | Brook trout | Tiger muskellunge |
| 2 | – | – | – | | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 3 | – | – | – | 9 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 4 | – | – | – | 40 | – | – | – | 1 | – | – | – | – | – | – | – | – | – | – | – | 4 | – | – | – | – | – | – | – | – |
| 5 | – | – | – | 65 | – | – | – | 1 | – | – | – | – | – | – | 4 | – | 1 | – | – | – | 1 | – | – | – | – | – | – | – |
| 6 | 4 | – | – | 40 | – | – | – | 7 | – | – | – | – | 1 | – | 2 | – | 3 | – | – | – | – | – | – | – | 1 | – | – | – |
| 7 | 2 | – | 1 | 60 | – | 2 | – | 14 | – | – | 5 | – | 1 | – | 3 | – | – | – | – | – | 1 | – | – | – | – | – | – | – |
| 8 | – | – | – | 75 | 1 | 5 | – | 10 | – | 4 | 1 | – | 5 | 1 | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – |
| 9 | – | 1 | 3 | 69 | 7 | 10 | | 6 | – | 1 | 2 | – | 2 | – | – | 2 | – | 1 | – | – | – | – | – | – | 1 | – | – | – |
| 10 | 18 | – | 3 | 124 | 1 | 26 | – | 6 | – | 1 | – | – | 3 | – | – | 1 | – | 2 | – | – | – | – | – | – | – | – | 1 | – |
| 11 | 17 | – | 3 | 113 | 10 | 31 | – | 5 | – | – | – | – | 1 | – | – | 1 | – | – | – | – | – | – | – | – | – | – | – | 1 |
| 12 | 44 | – | 2 | 26 | 64 | 28 | – | 6 | – | – | 2 | 2 | – | – | – | – | – | – | 2 | – | – | – | – | – | – | – | – | – |
| 13 | 332 | 1 | 4 | – | 73 | 25 | – | 5 | – | – | – | 4 | – | – | – | 2 | – | 2 | – | – | – | – | – | – | – | – | – | – |
| 14 | 410 | – | 1 | – | 92 | 21 | – | 1 | – | – | – | – | – | – | – | – | – | – | 2 | – | – | – | – | – | – | – | – | – |
| 15 | 346 | – | 6 | – | 139 | 10 | 1 | – | – | 2 | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 16 | 367 | 2 | 19 | – | 68 | 1 | – | – | – | – | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 17 | 428 | 4 | 57 | – | 98 | – | – | – | – | – | 1 | 2 | – | – | – | – | – | – | – | – | – | – | 1 | – | – | – | – | – |
| 18 | 354 | 10 | 90 | – | 98 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 19 | 201 | 15 | 114 | – | 76 | – | 2 | – | 3 | 2 | 1 | 1 | – | 4 | – | – | – | – | – | – | – | – | 1 | – | – | 1 | – | – |
| 20 | 116 | 13 | 75 | – | 50 | – | 4 | – | – | 1 | – | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 | – | – |
| 21 | 53 | 21 | 41 | – | 10 | – | 9 | – | 2 | 3 | – | – | – | – | – | – | – | – | – | – | – | 1 | 1 | – | – | – | – | – |
| 22 | 22 | 21 | 8 | – | – | – | 14 | – | 4 | 4 | – | – | – | 1 | – | – | – | – | – | – | – | – | – | – | 1 | – | – | – |
| 23 | 13 | 22 | – | – | – | – | 20 | – | 5 | 1 | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Table 5.–Continued.

| Inch group | Species | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Walleyes | Northern pike | White sucker | Rock bass | Smallmouth bass | Brown bullhead | Golden redhorse | Yellow perch | Greater redhorse | Rainbow trout | Brown trout | Largemouth bass | Yellow bullhead | Bowfin | Pumpkinseed | Black bullhead | Bluegill | Black crappie | Lake herring | Logperch | Burbot | Common carp | Longnose gar | Muskellunge | Sea lamprey | Silver redhorse | Brook trout | Tiger muskellunge |
| 24 | 11 | 9 | – | – | – | – | 40 | – | 10 | 1 | 1 | – | – | 1 | – | – | – | – | – | – | – | 1 | – | – | – | – | – | – |
| 25 | 4 | 14 | – | – | – | – | 33 | – | 13 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 26 | 2 | 6 | – | – | – | – | 17 | – | 6 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 27 | – | 4 | – | – | – | – | 12 | – | 2 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 28 | – | 7 | – | – | – | – | 2 | – | 2 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 29 | 1 | 4 | – | – | – | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 30 | – | 6 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 | – | – | – | – |
| 31 | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 32 | – | 4 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 | – | – | – | – | – | – |
| 33 | – | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 34 | – | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 35 | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 36 | – | 2 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 37 | – | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 38 | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 39 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 40 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 44 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 | – | – | – | – |
| 51 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 | – | – | – | – |
| Total | 2,745 | 178 | 427 | 622 | 787 | 159 | 155 | 62 | 47 | 20 | 14 | 14 | 13 | 7 | 9 | 7 | 4 | 5 | 4 | 4 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 1 |

Table 6.–Estimates of abundance, angler exploitation rates, and instantaneous fishing mortality rates for Burt Lake walleyes and northern pike using the different methods described in text. Estimated 95% confidence intervals for estimates are given in parentheses.

| | Walleyes | Northern pike |
|---|---|---|
| Number tagged | 1,877 | 64 |
| Total tag returns | 161 | 5 |
| **Number of legal-size[a] fish:** | | |
| Multiple-census method | 13,622 (11,276–17,200) | 332 (166–53,586) |
| Single-census method | 32,295 (20,847–43,743) | 910 (64–2,261) |
| **Number of adult[b] fish:** | | |
| Multiple-census method | 21,832 (17,952–27,853) | 703 (445–1,682) |
| Single-census method | 42,032 (27,169–56,896) | 1,779 (64–4,154) |
| Wisconsin equation | 52,012 (16,820–160,830) | na |
| **Annual exploitation rates:** | | |
| Based on reward tag returns | 9.0% | 7.8% |
| Based on harvest/abundance[c] | 23.0% (13.8%–32.2%) | 33.8% (0%–86.2%) |
| **Instantaneous fishing rates (F):** | | |
| Based on reward tag returns | 0.1127 | 0.0966 |
| Based on harvest/abundance[c] | 0.2890 | 0.4186 |

[a] Walleyes ≥15 in and northern pike ≥24 in.
[b] Estimated numbers of fish, both legal size and sexually mature sub-legal size, on spawning grounds in April–May 2001.
[c] Single-census estimate of legal-size fish abundance.

Table 7.–Weighted mean lengths and sample sizes (number aged) by age and sex for walleyes collected from Burt Lake, April 19 to May 9, 2001. Standard deviations for mean lengths are in parentheses.

| | Mean length (SE) | | | | | | Number aged | | |
|---|---|---|---|---|---|---|---|---|---|
| Age | Males | | Females | | All[a] | | Males | Females | All[a] |
| 1 | – | | – | | 6.8 | (0.4) | | | 3 |
| 2 | – | | – | | 11.0 | (0.4) | | | 14 |
| 3 | 14.2 | (0.7) | 13.6 | (1.2) | 14.1 | (0.7) | 55 | 3 | 64 |
| 4 | 16.0 | (1.2) | 16.8 | (0.8) | 16.1 | (1.0) | 13 | 21 | 34 |
| 5 | 16.3 | (0.6) | 18.5 | (0.8) | 17.3 | (1.2) | 8 | 13 | 22 |
| 6 | 17.3 | (0.8) | 19.1 | (1.4) | 17.8 | (1.2) | 26 | 39 | 65 |
| 7 | 18.3 | (0.9) | 20.6 | (1.4) | 19.0 | (1.4) | 19 | 25 | 44 |
| 8 | 19.4 | (0.7) | 20.2 | (1.8) | 19.4 | (1.3) | 7 | 7 | 14 |
| 9 | 20.0 | (0.7) | 22.1 | (1.6) | 20.7 | (1.4) | 7 | 6 | 13 |
| 10 | 20.2 | (1.0) | 25.4 | (0.7) | 21.8 | (2.4) | 7 | 5 | 12 |
| 11 | 19.9 | (0.4) | 21.4 | (1.2) | 20.3 | (0.8) | 5 | 2 | 7 |
| 12 | 20.9 | (0.5) | 24.1 | (–) | 21.5 | (1.4) | 5 | 1 | 7 |
| 13 | 21.2 | (1.2) | 24.6 | (0.8) | 21.9 | (1.8) | 5 | 2 | 7 |
| 14 | 22.4 | (1.3) | | | 22.1 | (1.0) | 2 | | 2 |
| 15 | 23.0 | (0.3) | | | 23.0 | (0.3) | 4 | | 4 |
| 16 | 21.3 | (–) | | | 21.3 | (–) | 1 | | 1 |
| 17 | 22.4 | (–) | | | 22.4 | (–) | 1 | | 1 |
| 18 | 22.7 | (0.6) | | | 22.7 | (0.6) | 2 | | 2 |
| 19 | – | | | | – | (–) | – | | – |
| 20 | 22.2 | (–) | | | 22.2 | (–) | 1 | | 1 |

[a] Includes fish of unknown sex.

Table 8.–Weighted mean lengths and sample sizes (number aged) by age and sex for northern pike collected from Burt Lake, April 19 to May 9, 2001. Standard deviations for mean lengths are in parentheses.

| | Mean length (SE) | | | | | | Number aged | | |
|---|---|---|---|---|---|---|---|---|---|
| Age | Males | | Females | | All[a] | | Males | Females | All[a] |
| 1 | – | | – | | – | | – | – | – |
| 2 | – | | 18.1 | (0.6) | 17.4 | (1.9) | – | 2 | 4 |
| 3 | 21.2 | (1.9) | 21.7 | (2.5) | 21.6 | (2.6) | 16 | 19 | 43 |
| 4 | 21.4 | (2.8) | 23.3 | (3.4) | 23.5 | (4.2) | 7 | 6 | 20 |
| 5 | 22.8 | (1.2) | 27.9 | (2.1) | 24.2 | (2.5) | 6 | 2 | 14 |
| 6 | 25.8 | (–) | 30.2 | (3.0) | 28.6 | (3.1) | 1 | 7 | 10 |
| 7 | 28.8 | (4.8) | 26.8 | (4.7) | 28.8 | (4.2) | 2 | 2 | 7 |
| 8 | 24.6 | (0.6) | 34.7 | (4.4) | 29.6 | (6.3) | 2 | 5 | 9 |
| 9 | – | | – | | 37.0 | (1.1) | | | 2 |

[a] Includes fish of unknown sex.

Table 9.–Catch-at-age estimates (apportioned by length-age key) for walleyes and northern pike collected with trap and fyke nets and electrofishing gear from Burt Lake, April 19 to May 9, 2001.

| Age | Year-class | Walleyes Males | Walleyes Females | Walleyes All[a] | Northern pike Males | Northern pike Females | Northern pike All[a] |
|---|---|---|---|---|---|---|---|
| 1 | 2000 | – | – | 6 | – | – | – |
| 2 | 1999 | – | – | 32 | – | 3 | 7 |
| 3 | 1998 | 616 | 3 | 834 | 20 | 22 | 71 |
| 4 | 1997 | 260 | 44 | 486 | 10 | 7 | 34 |
| 5 | 1996 | 153 | 50 | 258 | 10 | 3 | 23 |
| 6 | 1995 | 526 | 126 | 652 | 1 | 8 | 18 |
| 7 | 1994 | 253 | 60 | 267 | 2 | 2 | 10 |
| 8 | 1993 | 47 | 15 | 69 | 2 | 6 | 13 |
| 9 | 1992 | 28 | 11 | 37 | – | – | 2 |
| 10 | 1991 | 24 | 7 | 30 | – | – | – |
| 11 | 1990 | 22 | 4 | 26 | – | – | – |
| 12 | 1989 | 14 | 2 | 18 | – | – | – |
| 13 | 1988 | 11 | 3 | 14 | – | – | – |
| 14 | 1987 | 2 | – | 3 | – | – | – |
| 15 | 1986 | 4 | – | 4 | – | – | – |
| 16 | 1985 | 1 | – | 2 | – | – | – |
| 17 | 1984 | 1 | – | 1 | – | – | – |
| 18 | 1983 | 2 | – | 2 | – | – | – |
| 19 | 1982 | 0 | – | 0 | – | – | – |
| 20 | 1981 | 1 | – | 1 | – | – | – |
| Totals | | 1,965 | 325 | 2,742 | 45 | 51 | 178 |

[a] Includes fish of unknown sex.

Table 10.–Walleye and northern pike tag returns (reward and non-reward) from Burt Lake by month for the angling season following tagging (April 28, 2001 – March 15, 2002). Percent of total tag returns is in parentheses.

| Month | Number of tag returns | | | |
|---|---|---|---|---|
| | Walleyes | | Northern pike | |
| January 2002 | 12 | (7.5) | 0 | (0) |
| February 2002 | 17 | (10.6) | 0 | (0) |
| March 2002 | 1 | (0.6) | 0 | (0) |
| April 2001 | 1 | (0.6) | 0 | (0) |
| May 2001 | 32 | (19.9) | 2 | (40) |
| June 2001 | 29 | (18.0) | 1 | (20) |
| July 2001 | 9 | (5.6) | 1 | (20) |
| August 2001 | 11 | (6.8) | 0 | (0) |
| September 2001 | 19 | (11.8) | 0 | (0) |
| October 2001 | 23 | (14.3) | 1 | (20) |
| November 2001 | 5 | (3.1) | 0 | (0) |
| December 2001 | 2 | (1.2) | 0 | (0) |
| Total | 161 | | 5 | |

Table 11.–Angler survey estimates for summer 2001 from Burt Lake. Survey period was April 28 through September 30, 2001. Two standard errors are given in parentheses.

| Species | Catch/hour | Apr–May | June | July | August | September | Season |
|---|---|---|---|---|---|---|---|
| | | Number harvested | | | | | |
| Rainbow trout | 0.0031 (0.0022) | 4 (1) | 16 (5) | 71 (90) | 86 (121) | 90 (111) | 267 (187) |
| Brown trout | 0.0004 (0.0008) | 37 (71) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 37 (71) |
| Smallmouth bass | 0.0013 (0.0010) | 42 (80) | 5 (2) | 0 (0) | 42 (10) | 25 (16) | 114 (82) |
| Walleyes | 0.0654 (0.0136) | 1,707 (709) | 1,162 (365) | 422 (273) | 763 (297) | 1,540 (563) | 5,594 (1,056) |
| Yellow perch | 0.2599 (0.0952) | 139 (175) | 193 (247) | 1,117 (966) | 3,405 (1,339) | 17,389 (7,725) | 22,243 (7,905) |
| White bass | 0.0001 (0.0003) | 0 (0) | 11 (27) | 0 (0) | 0 (0) | 0 (0) | 11 (27) |
| Northern pike | 0.0029 (0.0026) | 101 (204) | 0 (0) | 63 (21) | 82 (75) | 0 (0) | 246 (218) |
| Largemouth bass | 0.0000 (0.0000) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 4 (2) | 4 (2) |
| Rock bass | 0.0013 (0.0013) | 0 (0) | 0 (0) | 0 (0) | 95 (111) | 16 (23) | 111 (113) |
| Total harvest | 0.3345 (0.0979) | 2,030 (766) | 1,387 (441) | 1,673 (1,007) | 4,473 (1,383) | 19,064 (7,746) | 28,627 (7,982) |
| | | Number released | | | | | |
| Rainbow trout | 0.0002 (0.0001) | 0 (0) | 0 (0) | 11 (4) | 9 (3) | 0 (0) | 20 (5) |
| Smallmouth bass | 0.0080 (0.0045) | 146 (220) | 111 (139) | 209 (229) | 125 (121) | 91 (114) | 682 (384) |
| Largemouth bass | 0.0002 (0.0001) | 0 (0) | 0 (0) | 0 (0) | 20 (8) | 0 (0) | 20 (8) |
| Walleyes | 0.0119 (0.0039) | 18 (7) | 0 (0) | 156 (117) | 659 (281) | 184 (91) | 1,017 (318) |
| Northern pike | 0.0065 (0.0035) | 0 (0) | 0 (0) | 84 (143) | 334 (212) | 141 (151) | 559 (297) |
| Total release | 0.0269 (0.0072) | 164 (220) | 111 (139) | 460 (293) | 1,147 (372) | 416 (209) | 2,298 (580) |
| Total (harvest + release) | 0.3614 (0.0989) | 2,194 (797) | 1,498 (463) | 2,133 (1,049) | 5,620 (1,432) | 19,480 (7,749) | 30,925 (8,003) |
| | | Fishing effort | | | | | |
| Angler hours | | 18,081 (3,232) | 20,591 (3,784) | 20,441 (4,334) | 16,087 (2,655) | 10,370 (2,729) | 85,570 (7,619) |
| Angler trips | | 7,338 (1,468) | 8,649 (1,667) | 10,557 (2,254) | 8,865 (1,569) | 4,056 (1,114) | 39,465 (3,704) |

Table 12.–Angler survey estimates for winter 2002 from Burt Lake. Survey period was from January 1 through March 31, 2002. Two standard errors are given in parentheses.

| Species | Catch/hour | | January | | February | | March | | Season | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Number Harvested | | | | | | | |
| Brown trout | 0.0039 | (0.0032) | 122 | (140) | 59 | (48) | 7 | (5) | 188 | (148) |
| Walleyes | 0.0496 | (0.0239) | 1,645 | (956) | 723 | (414) | 42 | (51) | 2,410 | (1,043) |
| Yellow perch | 0.7570 | (0.2524) | 5,637 | (2,587) | 13,409 | (5,403) | 17,772 | (7,326) | 36,818 | (9,463) |
| Northern pike | 0.0010 | (0.0014) | 30 | (64) | 0 | (0) | 20 | (13) | 50 | (65) |
| Total harvest | 0.8115 | (0.2619) | 7,434 | (2,982) | 14,191 | (5,426) | 17,841 | (7,327) | 39,466 | (9,593) |
| | | | Number caught and released | | | | | | | |
| Largemouth bass | 0.0120 | (0.0117) | 585 | (557) | 0 | (0) | 0 | (0) | 585 | (557) |
| Walleyes | 0.0155 | (0.0087) | 416 | (303) | 279 | (236) | 61 | (75) | 756 | (391) |
| Northern pike | 0.0008 | (0.0008) | 29 | (50) | 11 | (11) | 0 | (0) | 40 | (51) |
| Yellow perch | 0.9721 | (0.9721) | 4,751 | (2,437) | 14,303 | (5,929) | 28,223 | (11,419) | 47,277 | (13,095) |
| Total catch and release | 1.0005 | (0.3450) | 5,781 | (2,910) | 14,593 | (5,996) | 28,284 | (11,419) | 48,658 | (13,222) |
| Total (harvest + release) | 1.8119 | (0.5107) | 13,215 | (4,174) | 28,784 | (8,087) | 46,125 | (13,568) | 88,124 | (16,337) |
| | | | Fishing effort | | | | | | | |
| Angler hours | | | 22,525 | (7,929) | 17,628 | (5,621) | 8,482 | (3,488) | 48,635 | (10,326) |
| Angler trips | | | 6,143 | (2,305) | 4,164 | (1,437) | 1,558 | (799) | 11,865 | (2,831) |

Table 13.–Angler survey estimates for summer and winter 2001–02 from Burt Lake. Survey period was April 28 to September 30, 2001 and January 1 to March 31, 2002. Two standard errors are given in parentheses.

| Species | Catch/hour | 2001 Apr–May | 2001 Jun | 2001 Jul | 2001 Aug | 2001 Sep | 2002 Jan | 2002 Feb | 2002 Mar | Season |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Number harvested | | | | | | | | |
| Rainbow trout | 0.0020 (0.0014) | 4 (1) | 16 (5) | 71 (90) | 86 (121) | 90 (111) | 0 (0) | 0 (0) | 0 (0) | 267 (187) |
| Brown trout | 0.0017 (0.0012) | 37 (71) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 122 (140) | 59 (48) | 7 (5) | 225 (164) |
| Smallmouth bass | 0.0008 (0.0006) | 42 (80) | 5 (2) | 0 (0) | 42 (10) | 25 (16) | 0 (0) | 0 (0) | 0 (0) | 114 (82) |
| Walleyes | 0.0596 (0.0124) | 1,707 (709) | 1,162 (365) | 422 (273) | 763 (297) | 1,540 (563) | 1,645 (956) | 723 (414) | 42 (51) | 8,004 (1,485) |
| Yellow perch | 0.4401 (0.1011) | 139 (175) | 193 (247) | 1,117 (966) | 3,405 (1,339) | 17,389 (7,725) | 5,637 (2,587) | 13,409 (5,403) | 17,772 (7,326) | 59,061 (12,331) |
| White bass | 0.0001 (0.0002) | 0 (0) | 11 (27) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 11 (27) |
| Northern pike | 0.0022 (0.0017) | 101 (204) | 0 (0) | 63 (21) | 82 (75) | 0 (0) | 30 (64) | 0 (0) | 20 (13) | 296 (228) |
| Largemouth bass | 0.0000 (0.0000) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 4 (2) | 0 (0) | 0 (0) | 0 (0) | 4 (2) |
| Rock bass | 0.0008 (0.0008) | 0 (0) | 0 (0) | 0 (0) | 95 (111) | 16 (23) | 0 (0) | 0 (0) | 0 (0) | 111 (113) |
| Total harvest | 0.5074 (0.1049) | 2,030 (766) | 1,387 (441) | 1,673 (1,007) | 4,473 (1,383) | 19,064 (7,746) | 7,434 (2,982) | 14,191 (5,426) | 17,841 (7,327) | 68,093 (12,479) |
| | | Number caught and released | | | | | | | | |
| Rainbow trout | 0.0001 (0.0000) | 0 (0) | 0 (0) | 11 (4) | 9 (3) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 20 (5) |
| Smallmouth bass | 0.0051 (0.0029) | 146 (220) | 111 (139) | 209 (229) | 125 (121) | 91 (114) | 0 (0) | 0 (0) | 0 (0) | 682 (384) |
| Largemouth bass | 0.0045 (0.0042) | 0 (0) | 0 (0) | 0 (0) | 20 (8) | 0 (0) | 585 (557) | 0 (0) | 0 (0) | 605 (557) |
| Walleyes | 0.0132 (0.0040) | 18 (7) | 0 (0) | 156 (117) | 659 (281) | 184 (91) | 416 (303) | 279 (236) | 61 (75) | 1,773 (504) |
| Northern pike | 0.0045 (0.0023) | 0 (0) | 0 (0) | 84 (143) | 334 (212) | 141 (151) | 29 (50) | 11 (11) | 0 (0) | 599 (302) |
| Yellow perch | 0.3523 (0.1032) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 4,751 (2,437) | 14,303 (5,929) | 28,223 (11,419) | 47,277 (13,095) |
| Total catch and release | 0.3797 (0.1051) | 164 (220) | 111 (139) | 460 (293) | 1,147 (372) | 416 (209) | 5,781 (2,910) | 14,593 (5,996) | 28,284 (11,419) | 50,956 (13,234) |
| Total (harvest + release) | 0.8871 (0.1599) | 2,194 (797) | 1,498 (463) | 2,133 (1,049) | 5,620 (1,432) | 19,480 (7,749) | 13,215 (4,174) | 28,784 (8,087) | 46,125 (13,568) | 119,049 (18,198) |
| | | Fishing effort | | | | | | | | |
| Angler hours | | 18,081 (3,232) | 20,591 (3,784) | 20,441 (4,334) | 16,087 (2,655) | 10,370 (2,729) | 22,525 (7,929) | 17,628 (5,621) | 8,482 (3,488) | 134,205 (12,833) |
| Angler trips | | 7,338 (1,468) | 8,649 (1,667) | 10,557 (2,254) | 8,865 (1,569) | 4,056 (1,114) | 6,143 (2,305) | 4,164 (1,437) | 1,558 (799) | 51,330 (4,622) |

Table 14.–General fish surveys conducted on Burt Lake by MDNR, Fisheries Division. Results of these surveys have not been published, but are available from MDNR, Fisheries Division.

| Time period | Purpose | Gears |
|---|---|---|
| August 28, 2001 | Walleye recruitment evaluation | Electrofishing |
| April 19–May 9, 2001 | Population estimates of predator game fish | Trap and fyke nets; electrofishing |
| Sept 10, 1997 | Walleye recruitment evaluation | Electrofishing |
| Sept 7, 1995 | Walleye recruitment evaluation | Electrofishing |
| April 17–May 8, 1995 | Fish community survey with emphasis on walleyes | Trap nets |
| April – September 1993 | Angler census | Anglers |
| April 13–23, 1991 | Walleye tagging program | Trap nets |
| April 24–30, 1990 | Walleye tagging program | Trap nets |
| April 22–29, 1985 | Walleye tagging program | Trap nets |
| April 22–30, 1980 | Walleye tagging program | Trap nets |
| July 18–Aug 14, 1975 | Creel census walleye collection | Angler survey |
| June 18–25, 1975 | Fish community survey with emphasis on walleyes | Gill nets |
| May 6–15, 1975 | Walleye tagging program | Trap nets |
| April and May 1971 | Walleye broodstock collection | Trap nets |
| April 29–May 8, 1970 | Walleye broodstock collection | Trap nets |
| May 8–23, 1969 | Fish community survey | Trap nets |
| July and August 1955 | Fish community survey | Gill nets and seining |
| July and August 1952 | Fish community survey | Gill nets |
| 1947–1949 | White sucker removals | Netting |
| July 1925 | Fish community survey | – |
| October 1887 | Fish community survey | – |

Table 15.–Mean lengths for walleyes from Burt Lake from our survey compared to previous surveys. See Table 21 for survey references. Number aged in parentheses.

| Age | State average[a] | Mean lengths from survey years | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2001[b] | 1995[c] | 1990[c] | 1985[c] | 1980[c] | 1975[c] | 1969[c] | 1955[c] |
| 1 | 7.1 | 6.8 (3) | | | | | 9.0 (1) | 6.1 (1) | 8.7 (10) |
| 2 | 10.4 | 11.0 (14) | | | 13.5 (9) | | 13.6 (3) | 11.7 (12) | 12.2 (27) |
| 3 | 13.9 | 14.1 (64) | 13.4 (59) | 13.9 (3) | 14.4 (12) | 14.4 (25) | 15.0 (40) | 12.8 (26) | 13.9 (24) |
| 4 | 15.8 | 16.1 (34) | 15.7 (76) | 15.0 (16) | 15.8 (15) | 16.2 (24) | 16.0 (32) | 16.5 (14) | 15.6 (9) |
| 5 | 17.6 | 17.3 (22) | 17.0 (42) | 16.1 (9) | 17.9 (25) | 18.0 (17) | 17.7 (27) | 17.0 (14) | 17.3 (23) |
| 6 | 19.2 | 17.8 (65) | 18.7 (67) | 17.4 (10) | 19.0 (14) | 18.9 (8) | 19.0 (24) | 17.3 (9) | 18.4 (15) |
| 7 | 20.6 | 19.0 (44) | 20.4 (69) | 18.6 (13) | 20.6 (13) | 19.8 (12) | 20.2 (21) | 19.3 (16) | 18.6 (12) |
| 8 | 21.6 | 19.4 (14) | 19.7 (39) | 19.5 (19) | 21.6 (8) | 21.1 (23) | 21.6 (17) | 20.9 (9) | 19.6 (4) |
| 9 | 22.4 | 20.7 (13) | 20.4 (22) | 21.1 (11) | 23.3 (14) | 23.0 (13) | 24.0 (5) | 21.0 (6) | |
| 10 | 23.1 | 21.8 (12) | 21.4 (28) | 22.8 (6) | | 23.3 (1) | 26.7 (1) | 23.3 (3) | |
| 11 | | 20.3 (7) | 22.2 (17) | | | | | 26.3 (1) | |
| 12 | | 21.5 (7) | 24.8 (4) | | | | 30.0 (1) | 24.5 (2) | |
| 13 | | 21.9 (7) | | | | | | | |
| 14 | | 22.1 (2) | | | | | | | |
| 15 | | 23.0 (4) | | | | | | | |
| 16 | | 21.3 (1) | | | | | | | |
| 17 | | 22.4 (1) | | | | | | | |
| 18 | | 22.7 (2) | | | | | | | |
| 19 | | – – | | | | | | | |
| 20 | | 22.2 (1) | | | | | | | |
| Mean growth index[d] | | -0.8 | -0.9 | -1.4 | +0.2 | 0.0 | 0.3 | -0.6 | 0.0 |

[a] Jan–May averages from Schneider et al. (2000).
[b] Fish aged with spines.
[c] Fish aged with scales.
[d] The mean deviation from the statewide quarterly average. Only age groups where N≥ 5 were used.

Table 16.–Mean lengths for northern pike from Burt Lake from our survey compared to previous surveys. See Table 21 for survey references. Number aged in parentheses.

| Age | State average[a] | Mean lengths from survey years 2001[b] | 1995[c] | 1985[c] | 1980[c] | 1975[c] | 1969[c] | 1955[c] |
|---|---|---|---|---|---|---|---|---|
| 1 | 11.7 | | | | | | 15.0 (2) | 13.8 (36) |
| 2 | 17.7 | 17.4 (4) | 17.1 (1) | | | 20.2 (1) | 17.9 (8) | 16.8 (64) |
| 3 | 20.8 | 21.6 (43) | | 21.3 (2) | | 21.5 (4) | 20.8 (15) | 19.6 (47) |
| 4 | 23.4 | 23.5 (20) | | 24.1 (5) | 23.4 (2) | 23.6 (3) | 22.5 (6) | 24.5 (8) |
| 5 | 25.5 | 24.2 (14) | | | | 27.7 (1) | 29.8 (3) | 25.8 (1) |
| 6 | 27.3 | 28.6 (10) | | | | 30.5 (1) | 30.9 (4) | 31.0 (1) |
| 7 | 29.3 | 28.8 (7) | | | | 32.0 (1) | 34.8 (1) | |
| 8 | 31.2 | 29.6 (9) | | | | | 29.2 (2) | |
| 9 | | 37.0 (2) | | | | 39.8 (2) | 35.0 (2) | |
| Mean growth index[d] | | -0.2 | – | +0.7 | – | – | -0.2 | +0.3 |

[a] Jan–May averages from Schneider et al. (2000).
[b] Fish aged with spines.
[c] Fish aged with scales.
[d] The mean deviation from the statewide quarterly average. Only age groups where N≥ 5 were used.

Table 17.–Comparison of recreational fishing effort and total harvest on Burt Lake to those of selected other Michigan lakes. Lakes are listed from highest to lowest total fishing effort. Lake size was from Laarman (1976).

| Lake, County | Size (Acres) | Survey period | Total fishing effort (Hours) | Fish harvested (Number) | Fish harvested per hour | Hours fished per acre | Fish harvested per acre |
|---|---|---|---|---|---|---|---|
| Michigan[a], many | – | Jan–Nov, 2001 | 2,684,359 | 677,360 | 0.25 | – | – |
| Huron[a], many | – | Jan–Oct, 2001 | 1,807,519 | 1,057,819 | 0.59 | – | – |
| Houghton, Roscommon (All year) | 20,075 | Apr 2001–Mar 2002 | 499,048 | 386,287 | 0.77 | 24.9 | 19.2 |
| Erie[a], Wayne and Monroe | – | Apr–Oct, 2001 | 490,807 | 378,700 | 0.77 | – | – |
| Houghton, Roscommon (Summer only) | 20,075 | Apr–Sep, 2001 | 278,214 | 325,148 | 1.17 | 13.9 | 16.2 |
| Superior[a], many | – | Apr–Oct, 2001 | 180,428 | 60,947 | 0.34 | – | – |
| Fletcher Pond, Alpena and Montmorency | 8,970 | May–Sep, 1997 | 171,521 | 118,101 | 0.69 | 19.1 | 13.2 |
| Burt, Cheboygan | 17,120 | Apr–Sep, 1993 | 134,957 | 20,734 | 0.15 | 7.9 | 1.2 |
| Burt, Cheboygan | 17,120 | April 2001–Mar 2002 | 134,205 | 68,473 | 0.51 | 7.8 | 4.0 |
| Gogebic, Ontonagon and Gogebic | 13,380 | May 1998–Apr 1999 | 121,525 | 26,622 | 0.22 | 9.1 | 2.0 |
| Mullett, Cheboygan | 16,630 | May–Aug, 1998 | 87,520 | 18,727 | 0.21 | 5.3 | 1.1 |
| Crooked and Pickerel, Emmet | 3,434 | April 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 |

[a] Does not include charter boat harvest or effort.

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Appendix.–Fish species captured in Burt Lake from 1952 through 2001 by MDNR crews using various gear types.

| Common name | Scientific name |
|---|---|
| Species we collected in 2001 with trap nets, fyke nets, and electrofishing gear | |
| Black bullhead | *Ameiurus melas* |
| Black crappie | *Pomoxis nigromaculatus* |
| Bluegill | *Lepomis macrochirus* |
| Bowfin | *Amia calva* |
| Brook trout | *Salvelinus fontinalis* |
| Brown bullhead | *Ameiurus nebulosus* |
| Brown trout | *Salmo trutta* |
| Burbot | *Lota lota* |
| Common carp | *Cyprinus carpio* |
| Golden redhorse | *Moxostoma erythrurum* |
| Greater redhorse | *Moxostoma valenciennesi* |
| Lake herring | *Coregonus artedi* |
| Largemouth bass | *Micropterus salmoides* |
| Logperch | *Percina caprodes* |
| Longnose gar | *Lepisosteus osseus* |
| Muskellunge | *Esox masquinongy* |
| Northern pike | *Esox lucius* |
| Pumpkinseed | *Lepomis gibbosus* |
| Rainbow trout | *Oncorhynchus mykiss* |
| Rock bass | *Ambloplites rupestris* |
| Sea lamprey | *Petromyzon marinus* |
| Silver redhorse | *Moxostoma anisurum* |
| Smallmouth bass | *Micropterus dolomieu* |
| Tiger muskellunge | *Esox lucius* × *Esox masquinongy* |
| Walleyes | *Sander vitreus* |
| White sucker | *Catostomus commersonii* |
| Yellow bullhead | *Ameiurus natalis* |
| Yellow perch | *Perca flavescens* |
| Additional species collected or observed in previous surveys of Burt Lake | |
| Alewife | *Alosa pseudoharengus* |
| Blackchin shiner | *Notropis heterodon* |
| Bluntnose minnow | *Pimephales notatus* |
| Central mudminnow | *Umbra lima* |
| Coho salmon | *Oncorhynchus kisutch* |
| Common shiner | *Luxilus cornutus* |
| Creek chub | *Semotilus atromaculatus* |
| Emerald shiner | *Notropis atherinoides* |
| Iowa darter | *Etheostoma exile* |
| Johnny darter | *Etheostoma nigrum* |
| Lake whitefish | *Coregonus clupeaformis* |
| Mimic shiner | *Notropis volucellus* |
| Sand shiner | *Notropis stramineus* |
| Sculpin sp. | *Cottus sp.* |
| Splake | *Salvelinus namaycush x Salvelinus fontinalis* |
| White bass | *Morone chrysops* |