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Abstract–Reliable roving interview catch rates require relative consistency of catch rate throughout individual angler trips and appropriate minimum fishing time prior to interview. One-half hour fishing time prior to interview has been the accepted minimum. Roving interview catch rates were evaluated for consistency of catch rates within angler trips and comparisons of roving interview catch rates to access interview catch rates were made. Simulation of a roving survey, using an access interview data set, gave a mere 2.1% underestimation of catch per hour when catch rate was constant within individual anglers' trips. When catch per hour increased within trips, catch per hour was underestimated by 40.1%. For two angler surveys, differences between access (ratio-of-means estimator) and roving (mean-of-ratios estimator) estimates were reduced when minimum-fishing time for roving interviews was increased from 0.5 h to 1.0 h. For 1.0-h minimum fishing time for roving interviews, total catch per hour for across data set comparisons of an Au Sable River angler survey was 0.1119 for access interviews and 0.1281 for roving interviews, and these were significantly different ($P=0.009$). Eight percent of 350-paired comparisons were significantly different ($P\leq0.05$). Roving interview catch rates were greater than access interview catch rates for 4.6% of comparisons and less than access interview catch rates for 3.4%. For Lake Gogebic angler survey with 1.0-h minimum fishing time for roving interviews, across data set catch rates were 0.0675 for access interviews and 0.0699 for roving interviews, and were not significantly different. For 99-paired comparisons, 13.1% of catch rates were significantly different ($P\leq0.05$). Roving interview catch rates were greater than access interview catch rates for 3.0% of comparisons and less than access interview catch rates for 10.1%. Comparison of minimum fishing time of 0.5 h and 1.5 h show greater differences. Similar to edge effect for area estimates, greater differences in catch rates when minimum fishing time was 0.5 h was attributed to start-up time effect. Conversely, when minimum fishing time was increased to 1.5 h, truncation of roving data set removed records with fishing times longer than some access interview trips. Within trip differences in catch rates were evaluated by comparing direct contact interviews for approximate first half of trip catch rate and post card survey for approximate latter-half of trip catch rate. Catch rates of six species were compared and only catch rates of yellow perch (*Perca flavescens)* were significantly different ($P=0.010$). Significantly greater catch rate during the latter portion of anglers' trips may be due to poor response rate from post cards (44.2%). Overall similarities between access and roving catch rates indicated reliability of roving interviews. Results indicated minimum-fishing time for Michigan roving interviews should be increased from 0.5 h to 1.0 h.

Introduction

Access and roving interviews are both routinely collected from Michigan sport fisheries to characterize angler catch and catch rates (e.g., Lockwood 2000c). Detailed descriptions of methods and estimators associated with these methods are given in Lockwood (2000a) and Lockwood et al. (1999), and follow estimation methods given in Pollock et al. (1994). The diverse nature of Michigan fisheries necessitates use of both interview types and consequently, the need for appropriate catch rate estimators to provide reliable catch estimates.

Typically, access interviews are collected at sites where anglers access the fishery from limited, well-defined locations and creel clerks are easily scheduled to sample these access sites and collect representative samples of angling activity. However, many Michigan angler surveys are conducted at lakes or rivers where anglers have seemingly unlimited access sites and these sites are not well defined. Anglers may, for example, access a fishery from cottages surrounding a lake. Here a clerk cannot effectively remain at one or a few locations in hopes of interviewing a representative sample of anglers. In other situations a fishery may be remote with anglers again accessing the fishery from less than obvious locations. Such remote fisheries often have fewer anglers present at any given time. Using access methods in such situations poses two critical concerns. First, if fewer anglers are interviewed, variability in the resulting estimates may be great and limit usefulness of survey results. Second, biased estimates result if the anglers interviewed are not representative of the population of anglers fishing at that location.

Following the access design, clerks are scheduled to remain at access locations at varying times of the day and typically they remain at a location longer than the average angler trip length. These methods serve to remove trip length bias. That is, anglers are not more or less likely to be interviewed based on the length of their fishing trip.

From access interviews an unbiased catch rate (catch per hour) is estimated using the ratio-of-means estimator (Jones et al. 1995; Lockwood 1997). Access interviews may be collected by angler or angler party.

When access interview methods are not practical or appropriate, roving interview methods are employed. Using roving methods, the clerk moves through the survey area and interviews anglers as they fish. Assuming that anglers do not intentionally avoid the clerk and none are hidden from view, all anglers are available for interviewing – regardless of access origin. Length of fishing trip (from start to time of interview) is recorded as well as number of fish caught. This information is recorded by angler rather than angler party to avoid party size bias (Lockwood 1997). Catch rate is estimated using the mean-of-ratios estimator (Lockwood et al. 1999; Pollock et al. 1997).

Using roving methods, anglers that remain at a site longer have a greater probability of being interviewed. Consequently, trip length bias becomes a concern and appropriate catch-rate estimator is necessary. For example, using the ratio-of-means estimator with roving data would weight longer fishing trips more heavily than shorter trips. To illustrate trip length bias, consider an example set of 14 angler trips (completed) with varying starting and ending times (Figure 1). In this case, angler eight is present for a greater proportion of the day and would have the greatest probability of being interviewed. Anglers 4, 11 and 12 are present for the shortest periods and would have the lowest probability of being interviewed. If a clerk visited this example site at 0900h, anglers 2, 3, 6, 7, 8, and 14 would be interviewed. By averaging catch rates (i.e., mean-of-ratios) each angler's catch rate is weighted equally regardless of trip length.

Appropriate catch rate estimators to use with access and roving methods are only recently understood (Jones et al. 1995; Lockwood 1997). Prior evaluations of access and roving interview methods often failed to correctly calculate catch per hour for each method and did not always account for angler party size bias associated with roving methods. Lockwood (1984) compared access and roving catch rates using mean-of-ratios catch rate estimator and did not compensate for party size. Conversely, Malvestuto et al. (1978) compared access and roving catch rates using daily ratio-of-means estimator. Crone and Malvestuto (1991) compared catch rates from five catch rate estimators based on roving interviews. Their assumption that catch rate and trip length are independent may have accounted for differences they observed between mean party estimator (party mean-of-ratios) and total ratio estimator (ratio-of-means). Similarly, Zweifel and Stanovick (2003) reported underestimation of harvest rates when using ratio-of-means estimator with roving interviews.

An important assumption when collecting roving interviews, and using mean-of-ratios estimator, is that the expected catch rate is constant throughout any given angling trip. If catch per hour is consistently greater or lesser toward the end of fishing trips, roving methods give a biased estimate of catch rate.

Pollock et al. (1997) has shown that when bag limits are easily attained, more skilled anglers with greater catch per hour, and consequently shorter trips, are less likely to be interviewed. Catch rates from roving interviews in this situation would underestimate the catch per hour. Fierstine et al. (1978) showed no significant difference between 84 angling parties interviewed twice during their fishing trip, once while fishing and a second time as they completed their fishing trip.

Current Michigan bag limits are not easily attained and do not appear to influence trip length (Institute for Fisheries Research – unpublished data). However, consistencies of catch rates throughout anglers' fishing trips has not been measured and appropriate comparisons of access and roving catch rates has not been done.

Pollock et al. (1997) recommend 0.5 h minimum fishing time prior to collection of roving interviews. To date, minimum fishing time criteria has not been evaluated. Michigan angler surveys record start of trip as time the angler arrived at the fishing location not time lures or baited hooks were first placed in the water. Thus, some amount of preparation time exists at the beginning of a trip.

The objective of this current study is to evaluate potential for bias caused by variation in catch rates within trips using simulation, and to compare paired access and roving creel estimates under different minimum trip lengths (using their appropriate catch rate estimators) by bootstrapping.

Methods

Simulation of varying catch rates within trips

To compare roving methods with access methods, a data set with 14 access interviews was selected (see Figure 1 for trip length times). Catch per hour using the ratio-of-means estimator was calculated as (Jones et al. 1995; Lockwood 1997):

$$\hat{R}_i = \frac{\sum_{j=1}^{n} c_{ij}}{\sum_{j=1}^{n} h_j} = \frac{\sum_{j=1}^{n} c_{ij} \Big/ n}{\sum_{j=1}^{n} h_j \Big/ n} = \frac{\overline{c_i}}{\overline{h}}, \qquad (1)$$

for catch c of species i with h hours fished by n anglers (or angler parties). Catch per hour for the data set was 0.3023 (Table 1). Start time and end time for each angler are included in the data set. Roving surveys were simulated for two cases. First for a fishery with catch rates being constant throughout each angler's fishing trip; and second for a fishery with catch rates increasing from the beginning to the end of each fishing trip. For the first case, the trip catch rate for a given interview was assigned to every hour that angler fished. Figure 2 illustrates an example of a constant catch rate during a 4 h fishing trip. In the second case, the catch per hour increased from 0.00 during the first hour to the completed-trip catch rate during the last hour fished for a given interview. Figure 3 illustrates an example of increasing catch rate during a 4 h fishing trip. Catch rate of 1.00 at the end of hour 4 is the completed-trip catch rate – not the catch rate during that hour.

To simulate a roving survey, various times of day were randomly selected to sample anglers. From Figure 1, times were hours between 0600 h and 1900 h. Mean-of-ratios catch rates for constant and increasing catch rates were calculated for each angler present during a randomly selected time, the catch rates were stored and this process was repeated 10,000 times. Mean-of-ratios catch rate was estimated as (Pollock et al. 1997; Lockwood et al. 1999):

$$\overline{R}_i = \frac{\sum_{j=1}^{n} \left(c_{ij} / h_j \right)}{n}, \qquad (2)$$

for n anglers. Similar to a roving survey, anglers that fished longer had a greater probability of being sampled.

Access and roving catch rate comparisons from angler surveys

To further evaluate roving methods, angler catch data from two angler surveys conducted during 1999 were selected. Each survey collected both access and roving interviews, and similar numbers of both access and roving interviews were collected. Catch data from each survey were collected by angler rather than by angler party. While these fisheries are not intended to be representative of all Michigan fisheries, they are typical examples of fisheries where roving methods would be used. Only data having catch per hour >0 for one or both interview data sets (roving or access) were used.

Stratification of interview data followed standard methods used in Michigan inland angler surveys (e.g., Lockwood 2000c) and strata are described as follows: Each survey area was stratified into smaller areas or stretches; multiple-day periods were used with weekdays and weekend days as periods within months (or approximate month periods); fishing mode; and catch or harvest data by species (Lockwood et al. 1999). An individual strata could be, for example, catch of bluegills by open ice anglers during January weekdays within a given lake area. Only anglers that fished a minimum of 0.5 h were interviewed (Pollock et al. 1997).

Au Sable River – summer 1999– Using methods for a multiple-day period (Lockwood et al. 1999), angler creel surveys were conducted at nine sections (34 river miles) of the Au Sable River and on three Au Sable River impoundments (Figure 4). Survey data were collected during spring to fall months in 1999. Both harvested and caught-and-released fish were recorded by species. Two modes of angling were sampled (boat and shore/wading) over a 5-month period. Anglers were either interviewed as they fished (roving interview) or at the completion of their trip (access interview). No anglers were interviewed as they fished and then again at the completion of their trip. All interviews, regardless of type, were by individual angler. Additional survey descriptions may be found in Lockwood (2000b) and Lockwood (2001).

Lake Gogebic–winter 1999–An angler creel survey was conducted on Lake Gogebic (13,192 acres) during winter months 1999 using multiple-day period methods (Lockwood et al. 1999). The lake was stratified into three grids (Figure 5). Survey data were collected between January 4 and April 10, 1999. Both harvested and caught-and-released fish were recorded by species. Two modes of angling were sampled (open ice and shanty) during the survey period. Anglers were either interviewed as they fished (roving interview) or at the completion of their trip (access interview). No anglers were interviewed as they fished and then again at the completion of their trip. All interviews, regardless of type, were by individual angler. Additional survey descriptions may be found in Lockwood (2000c).

Comparisons of access and roving catch rate estimates from Au Sable River or Lake Gogebic surveys were made by strata. Access catch rates were estimated using a ratio-of-means estimator $\hat{R}$ (1) and roving catch rates estimated using a mean-of-ratios estimator $\overline{R}$ (2).

Bootstrapping techniques with 10,000 replications were used to calculate estimated within-data-set difference in catch rates. The percentile method for detecting differences in catch rate was used and differences were considered statistically significant when zero was not included in the central 95% bootstrap differences (Efron and Tibshirani 1993).

Distribution of catch rates frequently deviate from normality. The shape of bootstrap differences was evaluated to further assess asymmetry of percentile confidence limits. Efron and Tibshirani (1993) measured shape as:

$$shape = \frac{\hat{\theta}_{up} - \hat{\theta}}{\hat{\theta} - \hat{\theta}_{lo}}, \qquad (1)$$

where, $\hat{\theta}$ is the estimated difference between access and roving interview catch rates, and

$\hat{\theta}_{up}$ and $\hat{\theta}_{lo}$ are the upper and lower 95% limits. Shape >1.00 indicates a greater distance between $\hat{\theta}_{up}$ and $\hat{\theta}$ than between $\hat{\theta}_{lo}$ and $\hat{\theta}$, and is skewed to the right. Similarly, shape <1.00 indicates a greater distance between $\hat{\theta}_{lo}$ and $\hat{\theta}$ than between $\hat{\theta}_{up}$ and $\hat{\theta}$, and is skewed to the left. Symmetrical intervals have shape=1.

Across dataset differences were evaluated using Wilcoxon signed-ranks test (Ferguson 1976). Access and roving catch rates were paired by strata. Ratio-of-means catch per hour for access interviews and mean-of-ratios catch per hour for roving interviews were calculated, appropriately, for each data set. The two surveys (Au Sable River and Lake Gogebic) were considered and evaluated separately.

Within trip catch rate comparisons

To further evaluate within trip catch rates, post cards were randomly distributed to Lake Gogebic anglers during 1999 survey. Each card was self addressed and post paid. Cards were given to approximately every 7th angler. On each distributed post card, the clerk recorded the area (grid) of the lake the angler was fishing in, month, day, start time of the fishing trip (reported to the clerk by the angler), and number of fish harvested by species. The angler was also given a pencil and asked to record the time the fishing trip ended, and the number of fish harvested after receiving the card, and drop the completed card in a U. S. Postal mail box. Fish caught and released were not included. Each card had a unique number, which was recorded on the clerk's interview form. Post cards could then be tied to the clerk's interview form. From these records, catch rates, by species, could be measured during the initial portion and the latter portions of anglers' fishing trips. Differences were evaluated using Wilcoxon signed-ranks test.

Results

Simulation

For the simulation with constant catch rates, the resulting mean estimate of catch per hour was 0.2959, a mere 2.1% underestimation of the actual catch per hour of 0.3023 (Table 1). However, for the second simulation with increasing mean catch rates the catch per hour of 0.1810 underestimated actual catch per hour by 40.1%.

Access and roving catch rate comparisons from angler surveys

Au Sable River–Catch rate comparisons were made for 362 paired data sets (*N*). Species reported in the Au Sable River angler survey are given in Table 2. Number of access interviews per data set varied from 3 to 79 records. Mean number of access interview records was 21.3 and SD = 17.6. Length of completed fishing trip varied from 0.5 h to 13.3 h (Figure 6) with mean 3.2 h and SD = 2.4 h. Number of roving interviews per data set varied from 3 to 98 records. Mean number of roving interview records was 26.7 and SD = 22.2. Length of incompleted-fishing trip varied from 0.5 h to 16.5 h (Figure 7) with mean 2.6 h and SD = 2.3 h. Trip length distributions were significantly different (χ^2=1,068.8, df=21, P<0.001).

Mean catch rate of roving interview data sets was 0.1471 and mean catch rate of access interview data sets was 0.1080. Mean catch rate of roving interview data sets was significantly greater than mean catch rate of access interview data sets more often than expected by chance (Wilcoxon Signed Ranks Test, *N*=362, *P*=0.001). Differences between mean catch rates was -0.0391 (SD=0.0032). Distribution of differences is given in Figure 8.

For the 362 within data set catch rate comparisons, 33 (9.1%) catch rates were significantly different ($P \leq 0.05$). Mean-of-ratios estimate ($\bar{R}$) from roving interviews was significantly greater than ratio-of-means estimate ($\hat{R}$) from access interviews 20 times (Table 3). Ratio-of-means estimate ($\hat{R}$) from access interviews was significantly greater than mean-of-ratios estimate ($\bar{R}$) from roving interviews 13 times.

The Au Sable River data were re-analyzed with roving interview records with trip lengths <1.0 h removed from the data set. Previously, 0.5 h minimum trip length was considered adequate for roving interviews (Pollock et al. 1997). The resulting data set now contained 350 paired data sets. While no access interview records were removed due to trip length, paired data sets with catch rates of zero for both access and roving interviews were not included. Not comparing catch rates of zero followed initial selection criteria. Number of roving interviews per data set varied from 3 to 72 records. Mean number of roving interview records was 21.2 and SD = 17.7. Length of incompleted fishing trip varied from 1.0 h to 16.5 h with mean 3.1 h and SD = 2.3 h.

The mean catch per hour of roving interview data sets was 0.1281 and mean catch per hour of access interview data sets was 0.1119. Mean catch rate of roving interview data sets was significantly greater than mean catch rate of access interview data sets more often than expected by chance (Wilcoxon Signed Ranks Test, N=350, P=0.009). Differences between mean catch rates was -0.0162 (SD=0.2500). Distribution of differences is given in Figure 9.

For the 350 within data set catch rate comparisons, 28 (8.0%) catch rates were significantly different ($P \leq 0.05$). The mean-of-ratios estimate from roving interviews was significantly greater than the ratio-of-means estimate from access interviews 16 times (Table 3). The ratio-of-means estimate from access interviews was significantly greater than the mean-of-ratios estimate from roving interviews 12 times.

A third analysis removed roving interviews of less than 1.5 h. Now minimum roving interview fishing time was 1.5 h. This further reduced paired comparisons to 336 paired data sets. As with previous roving trip length reduction, no access interview records were removed due to trip length, and paired data sets with catch rates of zero for both access and roving interviews were not included. Number of roving interviews per data set varied from 3 to 60 records. Mean number of roving interview records was 15.8 (SD = 13.3). Length of incompleted fishing trip varied from 1.5 h to 16.5 h with mean 3.7 h and SD = 2.4 h.

Mean catch per hour of roving interview data sets was 0.1429 and mean catch per hour of access interview data sets was 0.1000. In this case, across data sets mean catch rate of roving interview data sets was significantly greater than mean catch rate of access interview data sets (Wilcoxon Signed Ranks Test, N=336, P=0.017).

Lake Gogebic–Catch rate comparisons were made for 99 paired data sets. Species reported in the Lake Gogebic angler survey are given in Table 2. Number of access interviews per data set varied from 5 to 185 records. Mean number of access interview records was 44.1 and SD = 50.8. Length of completed fishing trip varied from 1.5 h to 11.5 h (Figure 10) with mean 5.4h and SD = 2.0. Number of roving interviews per data set varied from 3 to 55 records. Mean number of roving interview records was 26.2 and SD = 15.1. Length of incompleted-fishing trip varied from 1.0 h to 14.5 h (Figure 11) with mean 3.5 h and SD = 2.2 h.

No roving interviews with fishing time <1.0 h were collected. Thus, comparisons began for roving-interview fishing time ≥1.0 h. Mean catch per hour of roving interview data sets was 0.0699 and mean catch per hour of access interview data sets was 0.0675, and the mean catch rate for roving interview data sets did not differ from mean catch rate of access interview data sets significantly (Wilcoxon Signed Ranks Test, N=99, P=0.942). Differences between mean catch rates was -0.0024 (SD=0.0100). Distribution of differences is given in Figure 12.

For the 99 within data set catch rate comparisons, 13 (13.1%) catch rates were significantly different ($P \leq 0.05$). The mean-of-ratios estimate from roving interviews was significantly greater than the ratio-of-means estimate from access interviews 3 times (Table 4). The ratio-of-means estimate from access interviews was significantly greater than the mean-of-ratios estimate from roving interviews 10 times.

I reanalyzed the Lake Gogebic data excluding trips less than 1.5 h. This reduced paired comparisons to 95 paired data sets. As with previous roving trip length reduction, no access interview records were removed due to trip length, paired data sets with catch rates of zero for both access and roving interviews were not included. Number of roving interviews per data set varied from 4 to 47 records. Mean number of roving interview records was 24.2 and SD = 13.3. Length of incompleted-fishing trip varied from 1.5 h to 14.5 h with mean 3.8 h and SD = 2.1 h.

Mean catch per hour of roving interview data sets was 0.0720 and the mean catch per hour of access interview data sets was 0.0675, and these means were not significantly different (Wilcoxon Signed Ranks Test, N=95, P=0.928).

Shape of bootstrap differences

For the 362 Au Sable River comparisons with minimum roving time of 0.5 h, 202 bootstrap distributions had left skew, 2 had symmetrical distributions, and 158 had right skew (Table 5). The 350 Au Sable River comparisons with minimum roving time of 1.0 h resulted in 188 bootstrap distributions with a left skew, 4 were symmetrical, and 158 had right skew. For the 99 Lake Gogebic comparisons with minimum roving time of 1.0 h, 48 bootstrap distributions had a left skew and 51 a right skew. No symmetrical distributions were produced.

Within trip catch rate comparisons

A total of 217 postcards were distributed to Lake Gogebic anglers. Of these a total of 101 were returned, 5 of which were discarded for recording errors. Fishing effort during initial and latter portion of trips was similar (Table 6). Anglers fished, on average, 3.1 h during the initial period and 3.5 h during the latter period. All anglers fished a minimum of 0.5 h during each period.

Catch rates, by species, of 6 species of fish were compared (Table 7). Catch per hour of yellow perch was significantly greater during the latter period (Wilcoxon Signed Ranks Test, N=96, P=0.010), but catch rates for other species did not differ significantly. Catch per hour averaged across species, by initial and latter periods were 0.0795 for the initial and 0.1088 for the latter periods. No significant trend in direction of differences between these means was detected (Wilcoxon Signed Ranks Test, N=6, P=0.917).

Discussion

Use and interpretation of roving catch rates relies on two assumptions. First bag limits are not effective at reducing harvest. When bag limits are effective, more skilled anglers (having shorter fishing trips) are less likely to be interviewed. Current Michigan harvest limits are not overly restrictive. For example, to limit walleye harvest from inland lakes, bag limit would have to be reduced from current limit of 5 fish per day to 1 fish per day (J. Schneider, personal communication). Second is the assumption of catch rate consistency throughout anglers' trips. Simulation of a roving survey, with consistent catch rates for each angler, resulted in 2.1% underestimate of catch rate. However, when catch rates increased throughout individual trips, catch rate was underestimated by 40.1%. It is relatively easy to imagine a situation with decreasing catch rates and the resulting overestimation of actual catch per hour.

Fierstine et al. (1978) compared catch rates during the initial portion of anglers' trips with their final-total catch rate and found no significant differences. In this current study, post card data from Lake Gogebic anglers detected a significant increase in catch rate of yellow perch, but no significant difference in catch rate for 5 other species or for combined species. Poor response rate (44.2%) from anglers suggests that more successful anglers may have been more likely to respond.

Minimum recommended fishing time for collection of roving interviews in Michigan is currently 0.5 h (Lockwood 2000a) and follows recommendation by Pollock et al. (1997). At the beginning of a fishing trip anglers spend time preparing to actually fish (e.g., assembling and organizing fishing equipment). Catch rate during this initial period may not be representative of their entire trip. Similar to "edge effect" for area sampling, effect of initial fishing period preparation time may greatly influence roving catch rate when preparation time to actual fishing time ratio is too great. Increasing minimum fishing time for an interview to be used in catch rate calculation reduces preparation time effect. For the Au Sable River creel data, increasing minimum fishing time of roving interviews from 0.5 h to 1.0 h reduced significant differences across and within data sets. With minimum fishing time of 0.5 h, 90.9% of catch rate comparisons were not significantly different. For roving minimum trip length of 1.0 h, 92.0% and 86.9% of comparisons were not different for Au Sable River and Lake Gogebic, respectively. However, minimum allowable fishing time for roving interviews should not be so great as to reject trip lengths that are within the range of access trip lengths. Most Au Sable River access interviews (96.4%) and all Lake Gogebic access interviews had trip lengths ≥1.0 h.

Increasing roving minimum trip length to 1.5 h had unwanted results. From the Au Sable River survey, difference between access and roving catch rates increased to 42.9% and 23.3% of access interviews had trip lengths <1.5 h. For Lake Gogebic data, catch rates were not significantly different across data sets when minimum length of trip was increased to 1.5 h. However, difference between roving and access catch rate increased from 3.6% at 1.0 h minimum, to 6.7% at 1.5 h minimum.

Access trip length characteristics were different for the Au Sable River and Lake Gogebic fisheries sampled. For example, a greater proportion of the river anglers took shorter trips (minimum access trip length was 0.5 h). Thus, minimum roving trip length of 1.5 h was substantially longer than many access trips. Resulting roving catch rates measured angling population data sets that were truncated and not representative of the entire angling population. Minimum trip length for access interviews from the lake was much longer at 1.5 h. Thus, truncating the roving interview data set had lesser adverse effects.

Overall similarities in catch rates indicate reliability of both access and roving methods. Increasing or decreasing catch rates within fishing trips may vary seasonally, daily, or may be related to trip length. Currently, when both roving and access interviews are collected in Michigan angler surveys, the appropriate catch rate estimator is used with each interview type and a weighted average is calculated (Lockwood 2000c).

Percentile method for detecting differences in catch rate produced skewed distributions. However, Efron and Tibshirani (1993) noted that exact intervals are usually asymmetrical. These distributions also reflect the asymmetrical nature of catch rates. Means were provided for catch rate estimates. While statistics such as median or mode are often used to describe asymmetrical distributions, the mean is the appropriate statistic for expansion to estimate population parameters.

This current study's primary focus was on comparison of paired samples. What this study was unable to measure, however, was the accuracy of the access catch rate estimates used in these comparisons. The unbiasedness of the ratio-of-means estimator is well documented (Jones et al. 1995; Lockwood 1997). However, actual catch rate to estimated catch rate precision can vary. Newman et al. (1997) compared walleye catch rates from a census with access catch rates using stratified design methods. In this study differences in estimated catch rates varied from 15.5% to 86.0% of actual catch rate within strata and 9.8% for period total. Two of six time period estimates were significantly different ($P \leq 0.05$), while seasonal totals were not significantly different.

The recommendation of this current study is to increase minimum fishing trip length for Michigan roving surveys from 0.5 h to 1.0 h. Increasing minimum fishing time from 0.5 h to 1.0 h reduces preparation time effect on estimated roving catch rate and better reflects estimated access catch rates. Further study evaluating properties of within trip catch rates, to better understand roving estimates, is warranted.

Acknowledgments

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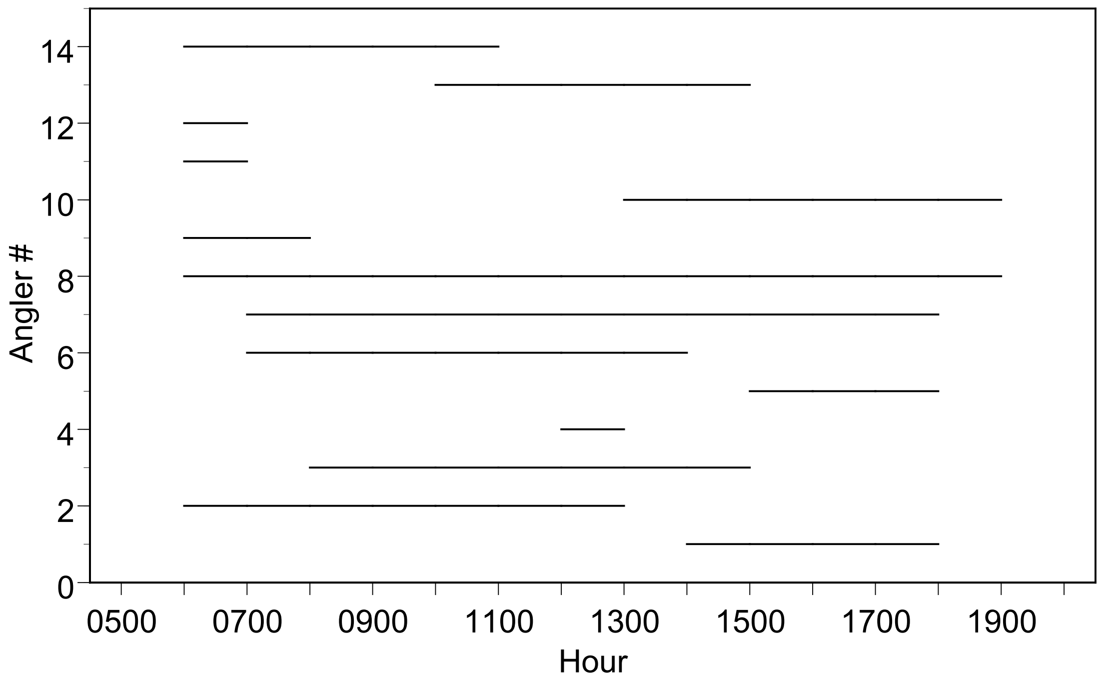

Figure 1.–Starting and ending times of fishing trips for 14 anglers.

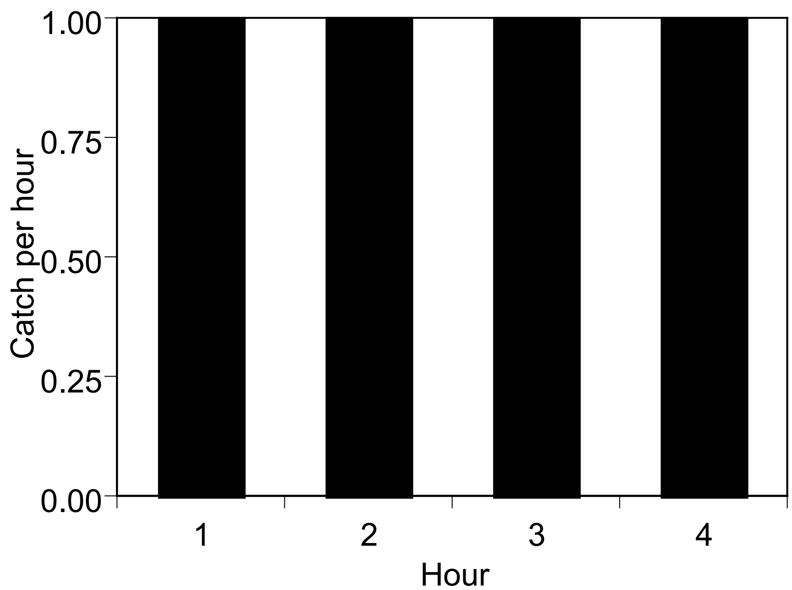

Figure 2.–Example of constant catch rate during a 4 hour fishing trip. Catch rate of 1.00 for each hour is the complete trip catch rate.

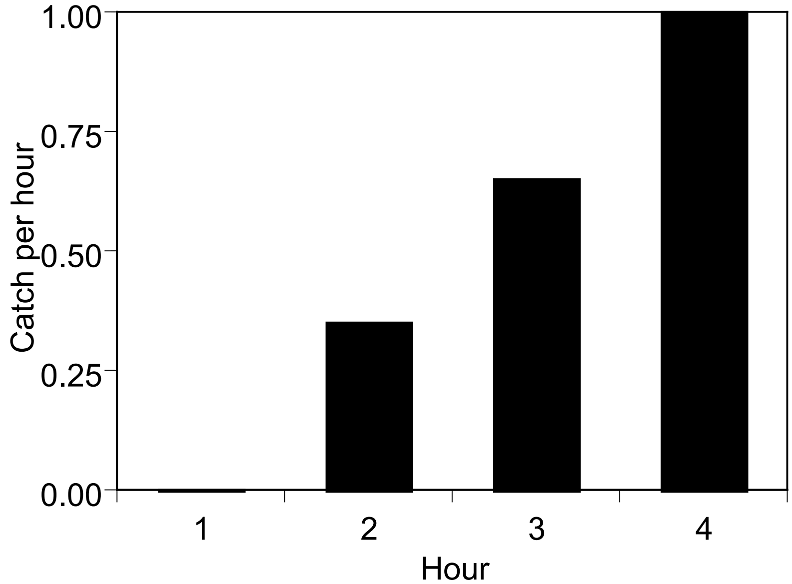

Figure 3.–Example of increasing catch rate during a 4 hour fishing trip. Final catch rate of 1.00 at the end of hour 4 is the complete trip catch rate.

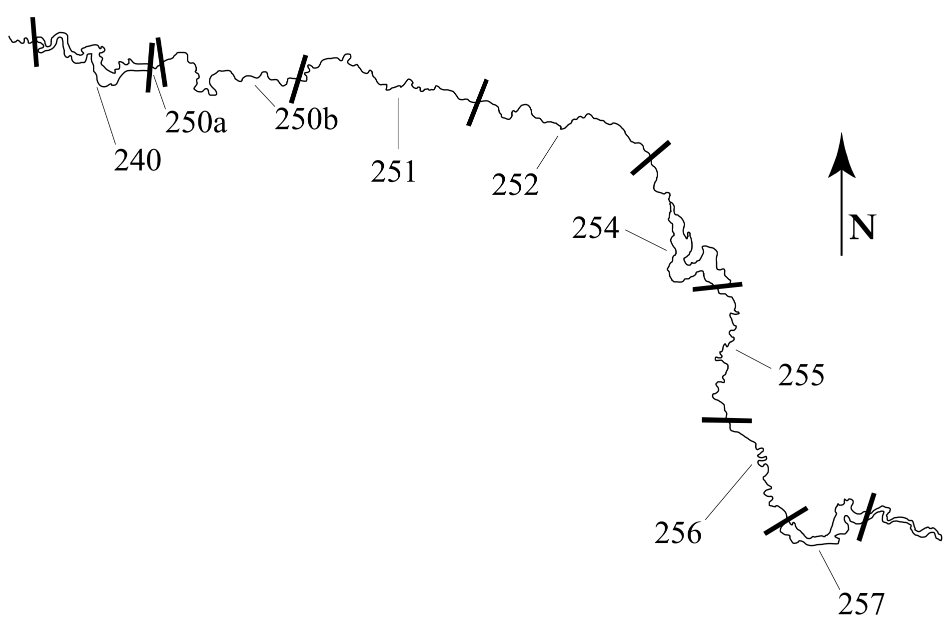

Figure 4.–Au Sable River sample sections, summer angler creel survey 1999. Dark bars indicate section boundaries.

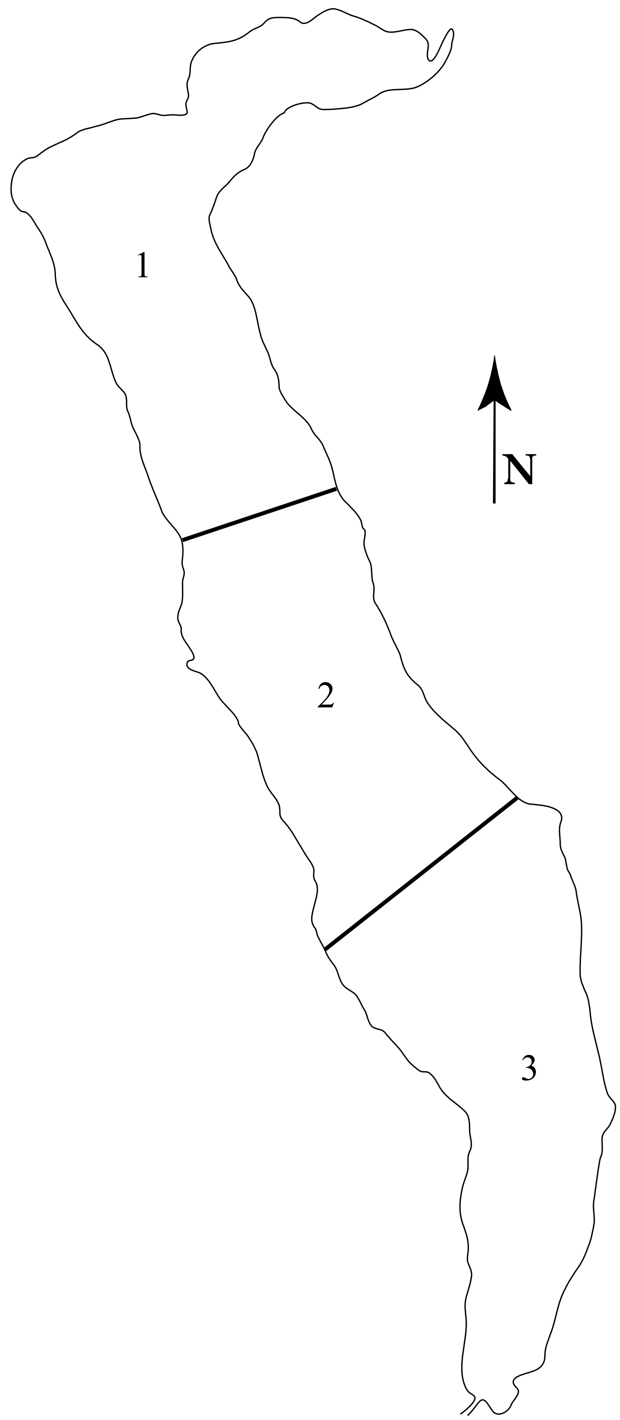

Figure 5.–Lake Gogebic sample grids, winter angler creel survey 1999.

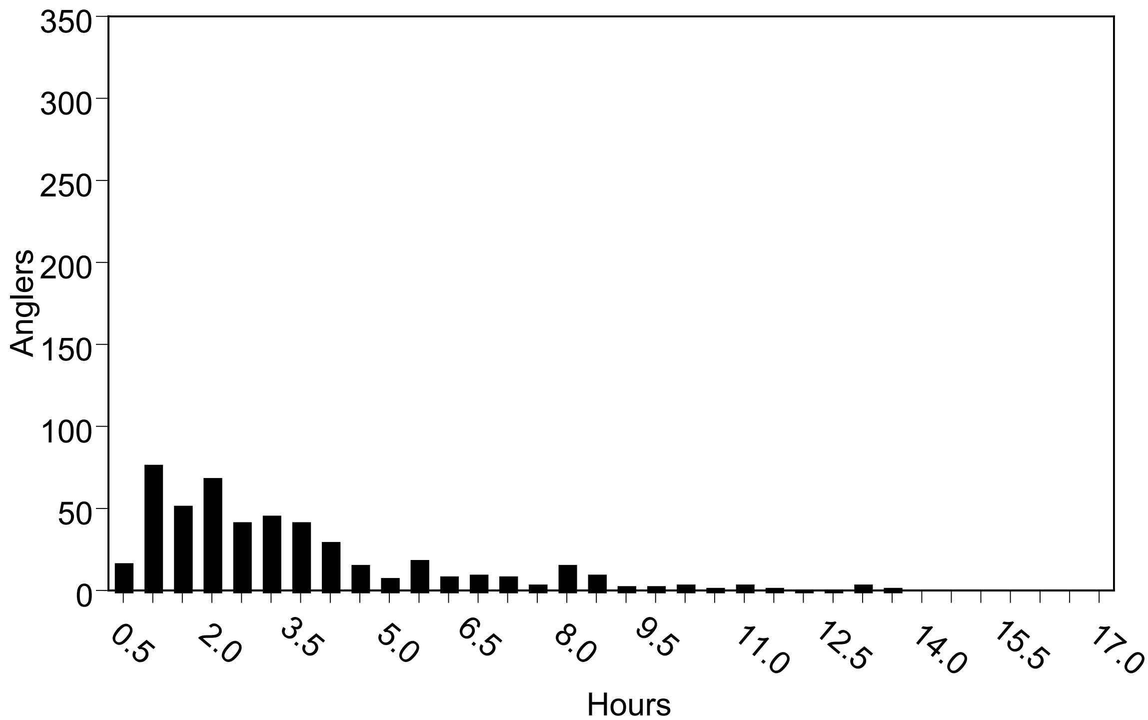

Figure 6.–Distribution of access interview trip length (completed trip) for anglers fishing in nine sections of the Au Sable River, summer 1999.

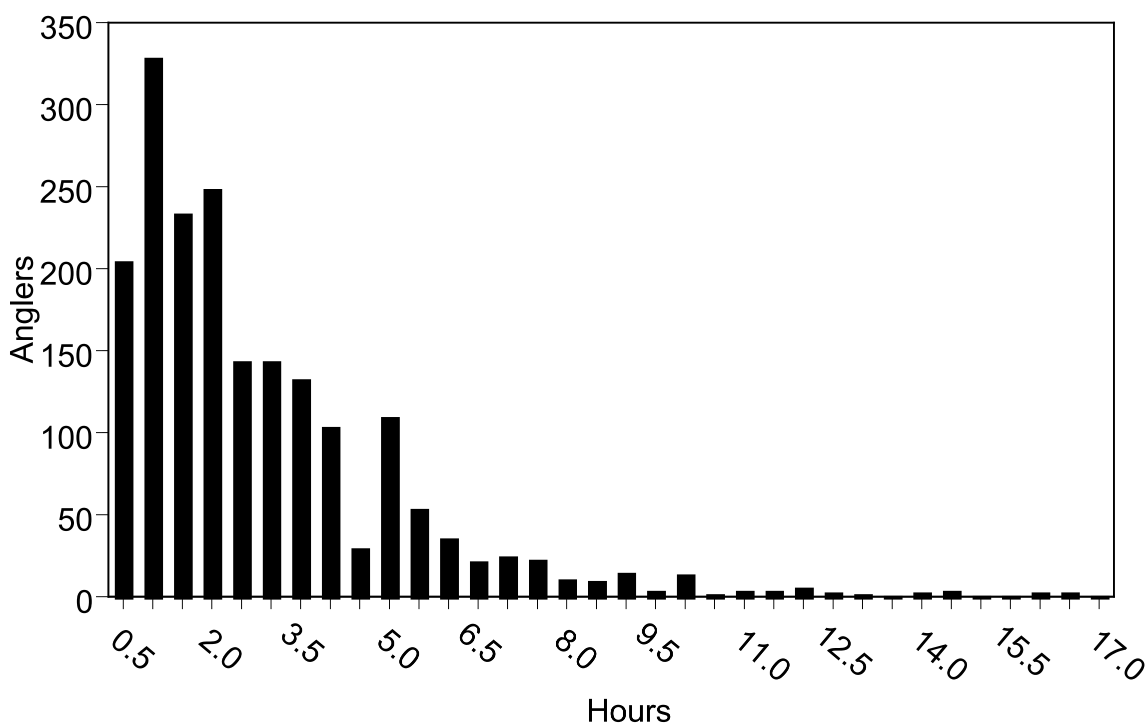

Figure 7.–Distribution of roving interview angling period until interviewed (incomplete trip) for anglers fishing in nine sections of the Au Sable River, summer 1999.

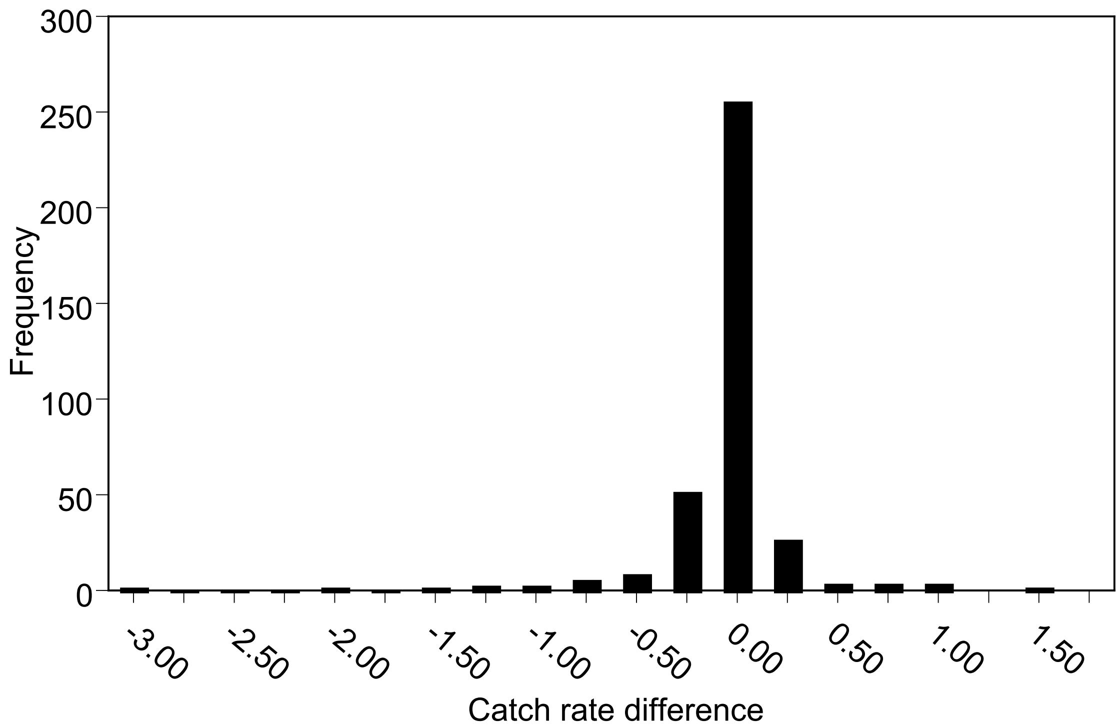

Figure 8.–Distribution of catch rate differences (access cph – roving cph), Au Sable River. Minimum fishing time prior to interview for roving interviews was 0.5 h.

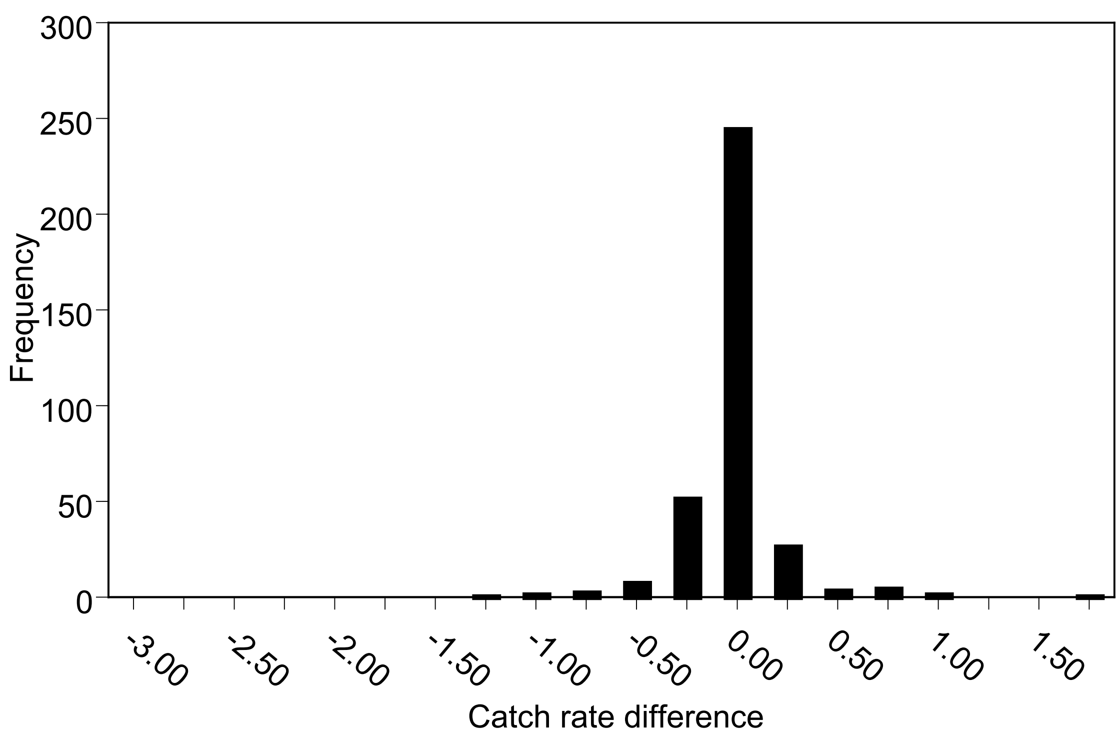

Figure 9.–Distribution of catch rate differences (access cph – roving cph), Au Sable River. Minimum fishing time prior to interview for roving interviews was 1.0 h.

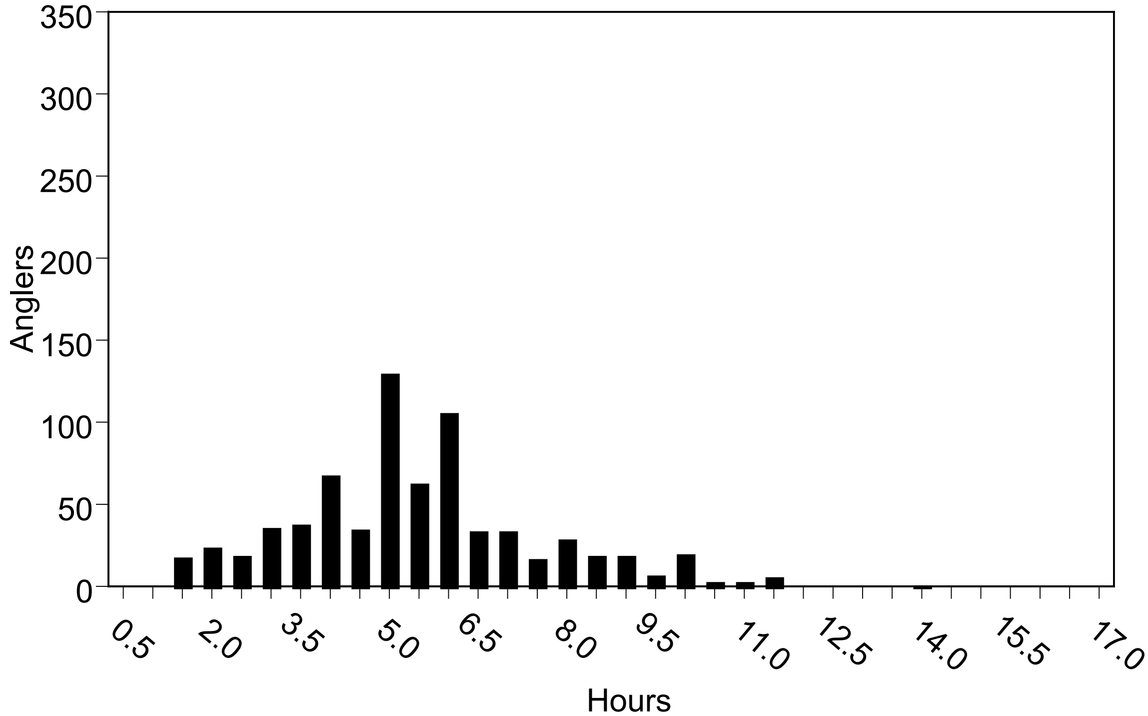

Figure 10.–Distribution of access interview trip length (completed trip) for anglers fishing in three sections of Lake Gogebic, winter 1999.

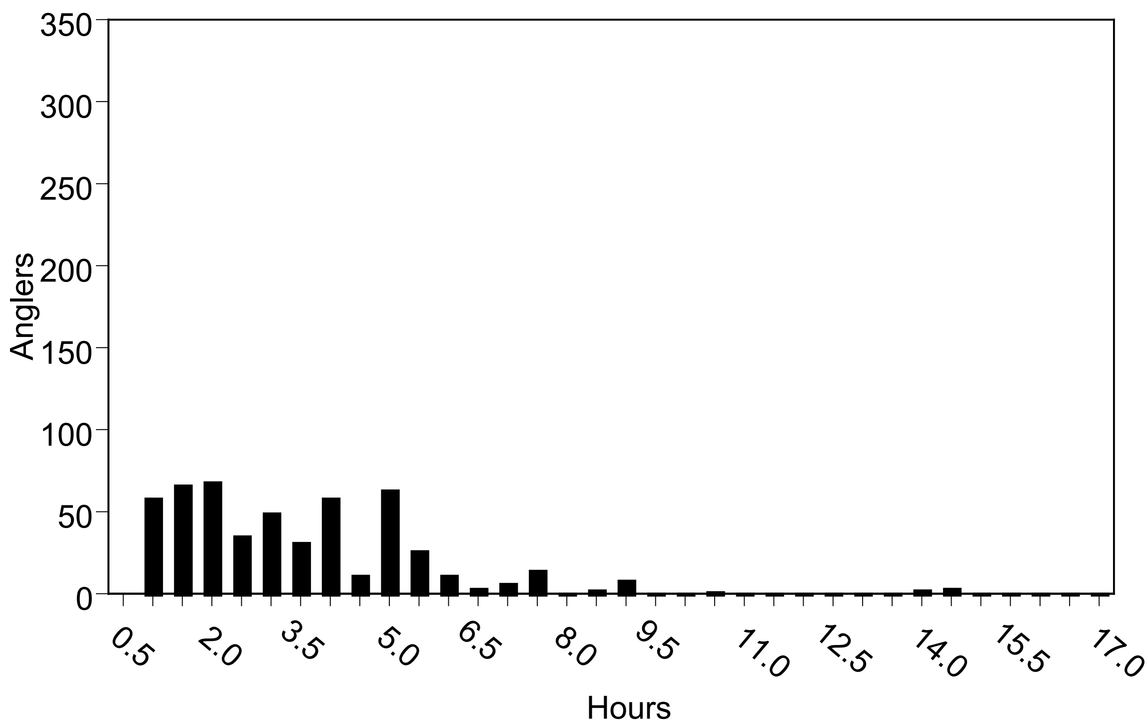

Figure 11.–Distribution of roving interview angling period until interviewed (incomplete trip) for anglers fishing in three sections of Lake Gogebic, winter 1999.

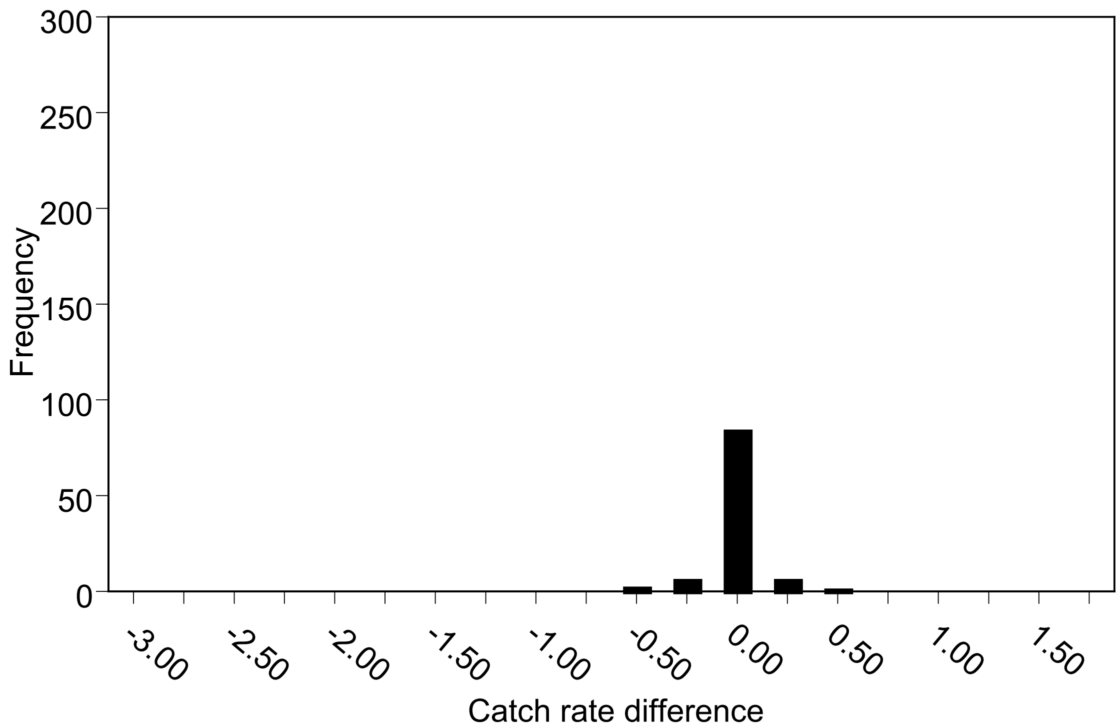

Figure 12.–Distribution of catch rate differences (access cph – roving cph), Lake Gogebic. Minimum fishing time prior to interview for roving interviews was 1.0 h.

Table 1.–Simulated catch rates for constant or increasing catch per hour within each angling record. Catch rates for constant or increasing catch per hour were based on 10,000 replications of the data set. Sample times were randomly selected for each record and the probability of a record being sampled was based on reported beginning and ending angling time for each record. Ratio-of-means estimator ($\hat{R}$) for data set; and mean-of-ratios estimator ($\overline{R}$), difference (Δ), and percent difference are given for constant and increasing rate of catch.

Data set		Constant rate of catch			Increasing rate of catch		
Records	$\hat{R}$	$\overline{R}$	Δ	Percent	$\overline{R}$	Δ	Percent
14	0.3023	0.2959	0.0064	2.1	0.1810	0.1874	40.1

Table 2.–Common and scientific names of fish reported in Au Sable River or Lake Gogebic 1999 angler surveys. Presence in a survey is indicated with an "X".

Common name	Scientific name	Au Sable River	Lake Gogebic
Black crappie	*Pomoxis nigromaculatus*		X
Bluegill	*Lepomis macrochirus*	X	
Brook trout	*Salvelinus fontinalis*	X	
Brown trout	*Salmo trutta*	X	
Bullhead spp.	*Ameiurus spp.*	X	
Catfish	*Ictalurus punctatus*	X	
Chinook	*Oncorhynchus tshawytscha*	X	
Chub spp.	*Nocomis sp.*	X	
Common white sucker	*Catostomus commersoni*	X	X
Crappie sp.	*Pomoxis sp.*	X	
Drum	*Aplodinotus grunniens*	X	
Lake herring	*Coregonus artedi*		X
Largemouth bass	*Micropterus salmoides*	X	
Northern pike	*Esox masquinongy*	X	X
Redhorse spp.	*Moxostomata spp.*	X	
Rainbow trout	*Oncorhynchus mykiss*	X	
Rock bass	*Ambloplities rupestris*	X	X
Smallmouth bass	*Micropterus dolomieu*	X	
Sunfish spp.	*Lepomis spp.*	X	
Tiger musky	*Esox lucius x masquinongy*	X	
Walleye	*Stizostedion vitreum*	X	X
Yellow perch	*Perca flavescens*	X	X

Table 3.–Au Sable River access and roving catch rate comparisons by bootstrapping. The current minimum roving trip length h=0.5 and two additional trip lengths were tested. Data are from nine river sections and were collected during summer 1999. Ratio-of-means estimator ($\hat{R}$), mean-of-ratios estimator ($\overline{R}$), and number of data sets compared (*N*) are given.

	Across data sets				Within data sets		
		Access	Roving		Bootstrap differences (P≤0.05)		
Minimum trip length (h)	*N*	$\hat{R}$	$\overline{R}$	Significance	$\hat{R}>\overline{R}$	$\hat{R}<\overline{R}$	Percent
<u>0.5</u>	362	0.1080	0.1471	0.001	13	20	9.1
1.0	350	0.1119	0.1281	0.009	12	16	8.0
1.5	336	0.1000	0.1429	0.017	-	-	-

Table 4.–Lake Gogebic access and roving catch rate comparisons by bootstrapping. The current minimum roving trip length is h=0.5. Two additional trip lengths were tested. Data are from three lake sections and were collected during winter 1999. Ratio-of-means estimator ($\hat{R}$), mean-of-ratios estimator ($\overline{R}$), and number of data sets compared (*N*) are given.

	Across data sets				Within data sets		
		Access	Roving		Bootstrap differences (P≤0.05)		
Minimum trip length (h)	*N*	$\hat{R}$	$\overline{R}$	Significance	$\hat{R}>\overline{R}$	$\hat{R}<\overline{R}$	Percent
<u>0.5</u>	-	-	-	-	-	-	-
1.0	99	0.0675	0.0699	0.942	10	3	13.1
1.5	95	0.0675	0.0720	0.928	-	-	-

Table 5.–Asymmetry (shape) of bootstrap intervals. Shape <1 indicate left skew, shape = 1 symmetrical distribution, and shape >1 right skew. Sample size (N) per data set are given.

Interview data set	Minimum fishing time	N	Shape		
			<1	1	>1
Au Sable	0.5 h	362	202	2	158
Au Sable	1.0 h	350	188	4	158
Gogebic	1.0 h	99	48	0	51

Table 6.–Fishing effort (hours) for 96 Lake Gogebic anglers voluntarily returning post cards.

	Portion of trip	
	Initial	Latter
Minimum fishing time	0.5	0.5
Maximum fishing time	7.5	10.5
Mean	3.1	3.5
Standard deviation	1.5	2.2

Table 7.–Catch per hour by species for angler returned post cards (Lake Gogebic).

Species	Catch per hour by trip period		P
	Initial	Latter	
Yellow perch	0.3768	0.5525	<0.010*
Black crappie	0.0017	0.0000	0.320
Rock bass	0.0104	0.0000	0.320
Northern pike	0.0304	0.0090	0.600
Walleye	0.0446	0.0914	0.090
Lake herring	0.0134	0.0000	0.180

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