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Roger N. Lockwood

Michigan Department of Natural Resources
Institute for Fisheries Research
Museums Annex Building
Ann Arbor, Michigan 48109-1084

Abstract.–The Lake Michigan angler survey currently uses the roving-access method for estimating angling effort and harvest at specific sites in State of Michigan waters. Sites are sampled with equal probability following a stratified random design. Four sampling techniques were evaluated to decrease sampling cost while maintaining or improving accuracy and precision of these estimates. Techniques were: determine site-to-site relationships for predicting angling effort; optimal allocation of clerk effort; proportional allocation of clerk effort; and bus route design. All four techniques were shown to be unsuitable replacements for current sampling techniques. Site-to-site relationships of angling effort were found to be inconsistent, while optimal allocation of clerk effort tended to direct more sampling effort towards sites having lower mean boat counts with greater variability. Proportional allocation of clerk effort provided inconsistent allocation based on boat angling effort and catch rates of walleye, yellow perch, or salmonines. Bus route design reduced number of survey clerks needed but increased overall cost of the survey.

Currently, estimates from specific sites are expanded to approximate lake-wide estimate for the year based on ratios from 1985 sample year. Updating and evaluation of 1985 ratios for expansion of sampled sites to approximate lake wide estimates is recommended. The ratios should be updated on a three-year interval.

The Michigan Department of Natural Resources, Fisheries Division conducts annual angler surveys at numerous sites along the Michigan waters of Lake Michigan. The purpose of these surveys is to estimate angling effort and harvest for the sport fishery (e.g., Rakoczy and Svoboda 1995). In addition to following annual trends in effort and harvest, data are used in conjunction with other research studies (e.g., Hesse 1994; Seelbach et al. 1994, Rybicki and Clapp 1996; Wesley 1996).

The Lake Michigan angler survey is described as a roving-access survey (Pollock et al. 1997). The survey clerk makes counts of angling effort (typically boat, shore or pier angling) from one or more vantage points at a site by "roving" within the bounds of the site, and anglers are interviewed as they complete their trip and are exiting the "access" site. This survey follows a stratified random sampling design and each site is sampled with equal probability. Either instantaneous or over-time interval counts are made to estimate angling

effort, and completed-trip interviews of angling parties are obtained to estimate harvest rate by species (Fabrizio et al. 1991). Current equations for estimating effort and harvest are given in Lockwood et al. (1998). For equations used prior to summer 1998, see Appendix 1 of Lockwood et al. (1998).

For each sample site, effort and harvest estimates were calculated by fishing mode (boat, shore or pier) within a time period (multiple days of a day type, for example). The sampled time periods and modes were then summed to provide seasonal estimates by sample site. Sample site estimates were then summed within a statistical district to provide an approximate district estimate. Maximum coverage of Lake Michigan sites occurred in 1985 (Fabrizio et al. 1991), and the 1985 data have provided a base-line for subsequent years when fewer sites were sampled. For sites not sampled in later years, effort and harvest were estimated by extrapolating from sampled sites based on between-site ratios measured in 1985. Site estimates were then summed to provide an approximate estimate by larger area such as Lake Michigan statistical district (Figure 1).

Access site methods for angler surveys (on-site), while expensive to administer, offer benefits which are often missing with off-site survey methods (Pollock et al. 1994) and directly relate to accuracy of the effort and harvest estimates. For example, a trained access site clerk verifies fish identification and enumeration, number of anglers in the party, and ending time of the fishing trip. Beginning time of the fishing trip is usually not verified by the clerk. Off-site methods include mail, phone and door-to-door surveys, and diaries or log books. These off-site methods may be substantially less expensive to administer, however, "Off-site methods depend on self-reported data and suffer from the vagaries of the anglers' memory, knowledge, and truthfulness." (Pollock et al. 1994:65).

Michigan used 9 seasonal fishery assistants (survey clerks) to sample 21 Lake Michigan sites and interview 14,397 angling parties during the 1 April to 31 October 1993 season (Rakoczy and Svoboda 1995). The cost for the Lake Michigan angler survey during this time period was approximately $250,000 (G. Rakoczy, personal communication).

The purpose of the present evaluation was to consider alternative sampling techniques to reduce cost of the Lake Michigan angler survey while maintaining reliability of the estimates, and to suggest methods for improving reliability of area-wide estimates.

Methods

Four different sampling or clerk allocation techniques were evaluated to improve efficiency of the Lake Michigan angler survey. Techniques were: (1) determination of utility for site-to-site relationships predicting angling effort; (2) optimal allocation of clerk effort; (3) proportional allocation of clerk effort; and (4) allocation of clerk effort following bus route design. Efficiency would be improved if a technique resulted in a reduction in number of clerks or cost, while maintaining or improving accuracy and precision of effort and harvest estimates.

Lake Michigan count and interview data sets were assembled for years 1985-96. Data were read into dBase IV files and each resulting file contained count or interview data for a single year. Individual records were identified by site (Figure 1), month, day of month, and fishing mode. Maximum annual sampling periods were 1 April through 31 October, with seasonal sites covering abbreviated periods. Interviews were recorded by angling party and all catch information was reported as number of fish harvested by species. Each interview record contained party catch for walleye *Stizostedion vitreum*, yellow perch *Perca flavescens*, and salmonines. The salmonines category represented the sum of lake trout *Salvelinus namaycush*, brown trout *Salmo trutta*, chinook salmon *Oncorhynchus tshawytscha*, coho salmon *Oncorhynchus kisutch*, steelhead salmon *Oncorhynchus mykiss* and pink salmon *Oncorhynchus gorbuscha* harvested by a given angling party. This category was created since angling methods were similar for all six species and these anglers often caught more than one salmonine species.

Twenty-nine sites in Michigan's eight statistical grids (MM-1 to MM-8) on Lake Michigan were selected for evaluation (Figure 1). These 29 sites represented the majority of sites sampled in 1985 and accounted for more than half the angling effort based on the 1985 survey (Fabrizio et al. 1991). Testing of each sampling method followed criteria that were practical in nature. For a method to be considered acceptable it must be appropriate in each statistical district. A sampling method that worked in one or some districts, but not in all districts, was not considered acceptable. Initial testing of each method was done using boat count data from a portion of the statistical grids. Further testing of a method was done when initial results indicated that the method was potentially suitable for all districts, angling modes, etc. All evaluations assumed 10 as the base-line number of survey clerks. (Note: Currently MM-2 is not sampled, but to more accurately estimate total Lake Michigan sport angling, MM-2 was considered in this sampling evaluation.)

Optimal and proportional allocation of clerk effort was done by site within each statistical district. The number of clerks per statistical district are given in Table 1 and are based on sampling recommendations by Fabrizio et al. (1991). Each monthly sampling schedule is based on 12 weekdays and 8 weekend days of sampling effort per clerk.

All techniques were evaluated using count and interview data on hand. Evaluations completed first were done with slightly fewer years of data. However, data used in each evaluation were considered representative of the Lake Michigan angler survey in general and appropriate for the method.

Site-to-site relationships

Potentially, relationships among sites would enable prediction of fisheries at unsampled sites and would reduce the number of survey clerks needed to conduct a Lake Michigan angler survey. Linear regressions were estimated for boat counts at sites in statistical district MM-8 (Figure 1) for the period 1986-94. All combinations of site pairs by time period were considered. All boat counts in MM-8 were interval type with count duration varying yearly from 0.25 h to 0.75 h. To evaluate on a count per minute basis, individual counts were divided by count duration for that count. Only counts with matching dates and times were used and periods were stratified by day-type (weekday or weekend day) within a month. Data from 1985 were not included in this evaluation because time of day of individual counts was not recorded. Relationships were considered significant when slope $b_1 \neq 0.0$ at $\alpha = 0.05$ and followed linear regression form with predicted site $\hat{Y}$ as

$$Y = b_0 + b_1 X , \qquad (1)$$

where X is the predictor site count and b_0 the vertical axis intercept.

Optimal allocation of clerk effort

Accuracy and precision of the Lake Michigan survey can potentially be improved by allocating clerk effort based on both magnitude and variability of boat counts at sites within a statistical district. Optimal allocation of angling effort was determined within statistical district MM-8 using interval boat count data 1985-95. To compare counts on a per minute basis, individual counts were divided by count duration for that count. To compensate for varying number of counts per day, count rates were averaged per day with period mean and standard deviation calculated from these daily averages. Optimal allocation of clerk effort E_1 at site p within a statistical district having h sites follows Cochran (1977) as

$$E_{1p} = C_{pi} \bullet \frac{\overline{N}_{pi} SD_{\overline{N}_{pi}}}{\sum_{k=1}^{h} \sum_{j=1}^{m} \overline{N}_{pkji} SD_{\overline{N}_{pkji}}} , \qquad (2)$$

where C is the number of clerk days available during period i with m counts having mean $\overline{N}$ and standard deviation SD. Cost of sampling each site was considered to be the same and

consequently cost was dropped from Cochran's (1977) original formula. Since clerks were not to be assigned partial work days (< 8 h) and only one site (unless otherwise noted) was to be sampled by a clerk during a day, practical sampling levels were established from E_1. Also, no site was to be sampled less than two days per time period.

Proportional allocation of clerk effort

Proportional allocation of effort directs more sampling effort to sites having greater mean boat counts or catch rates, relative to other sampling sites within that district, and should give the most accurate area-wide estimate per unit of cost. Allocation of clerk effort was based on boat counts and boat angler catch-per-hour rates of salmonines, yellow perch and walleye. All interviews were for completed trips and catch per hour was calculated using ratio-of-means estimator (Jones et al. 1995; Lockwood 1997). Evaluation was done for all 29 sampling sites within the 8 statistical districts. Each statistical district was considered separately and clerk effort was allocated to sites within a district. Maximum sampling period was 1 April to 31 October with some seasonal sites covering a shorter period. Proportional allocation of effort E_{2p} was calculated as in Cochran (1977)

$$E_{2p} = C_{pi} \bullet \frac{\overline{N}_{pi}}{\sum_{j=1}^{m} \overline{N}_{pji}}. \qquad (3)$$

Similar to optimal allocation, clerks were not to be assigned partial work days (< 8 h) and only one site (unless otherwise noted) was to be sampled by a clerk during a day, and practical sampling levels were established from E_2 with minimum sampling effort of two days per time period.

Bus route design

This method was appraised for potential reduction in number of clerks. Using this method, a clerk samples a selected group of sites following a schedule resembling a bus route schedule with each site analogous to a stop on a bus route schedule. The clerks wait at the assigned sites a given length of time to count and interview anglers. The beginning stop and order of the route varies randomly by sample day. Detailed descriptions of bus route design are given by Jones and Robson (1991) and Pollock et al. (1994).

The Lake Michigan angler survey area was driven to determine distance and driving time between sites. Three areas that could be covered by a single survey clerk were established based on distance and drive time. Sites 1 through 48 in statistical districts MM-1 and MM-2 were one coverage area; sites 80 to 100 in MM-3 and MM-4 the second; and sites 116 to 166 in MM-5 through MM-8 the third. Since anglers were not readily available for incompleted-trip interviews (Lake Michigan is primarily a boat fishery) only completed trip interviews could be collected and minimum wait time at each site was ≥1.0 h (Jones and Robson 1991).

Site locations along Lake Michigan are given in Figure 1; a bus route schedule with distances, drive times and wait times are given in Tables 2-4. Number of clerks needed for this method was adjusted by wait time per site and driving time between sites for each coverage area.

Results

Site-to-site relationships

Relationships between sites were significant for only 6 of 68 comparisons (Table 5). Site 162 boat counts were correlated with site 156 counts during July weekend days, and with site 166 counts during July weekdays. Site 164 counts were correlated with site 156 counts during July weekdays and October weekdays. Site 156

counts were correlated with site 160 counts during June weekdays and July weekend days.

Optimal allocation of clerk effort

Initial assumption was that sites with greatest mean boat counts (most angling effort) would have greatest SDs. Optimal allocation of effort then, would assign most clerk effort to sites with greatest angling effort, and inclusion of SD in equation 2 would further refine this allocation. However, results indicate that proportion of count variability and count magnitude is not always similar between sites. Based on this criterion, satisfactory allocation of clerk effort was realized for April weekdays and weekend days, May weekdays, June weekdays, July weekend days, August weekend days, September weekdays, and October weekend days. Disproportional count variability and magnitude resulted in inappropriate allocation of clerk effort for May weekend days, June weekend days, July weekdays, August weekdays September weekend days, and October weekdays.

Proportional allocation of clerk effort

Proportional allocation of clerk effort provided satisfactory sampling design for 5 of 8 statistical districts (Table 7). The sampling allocations by district are shown in Tables 8-15. Clerk allocations were based on count and catch rates from the periods 1985-95 and 1994-96. Similar allocations resulted from both periods and conclusions are based on most recent period, 1994-96.

Results were considered satisfactory when allocation of clerk effort, based on boat counts and each of the catch rates, were similar. The proportional allocation method resulted in reallocation of clerk effort in statistical districts MM-2, MM-4 and MM-7. Proportional allocation was not different from equal allocation in statistical districts MM-3 and MM-5. Contradictory sampling schedules resulted in statistical districts MM-1, MM-6 and MM-8.

Bus route design

Total number of clerks needed for the Lake Michigan angler survey was reduced from 10 to 8 using the bus route design (Tables 2-4). Minimum wait time per site varied from 1.16 to 2.90 h. Mean distance between sites was 23.4 ±11.5 miles (1 SD) and mean driving time between sites was 39.7 ±17.0 min (1 SD). Minimum total distance driven per day by all 8 clerks was 841.6 miles, and includes round trip mileage, by individual clerks, from first site sampled to last site sampled and return to first site. Minimum daily mileage cost, based on $0.25 per mile, was $210.40.

Discussion

On-site angler surveys are widely used and well accepted for estimating angling effort and catch from sport fisheries, and many techniques have been suggested for reducing cost and improving precision (e.g., Guthrie et al. 1991; Pollock et al. 1994). The goals of this evaluation of sampling techniques for the Lake Michigan angler survey were to explore alternative sampling methods that would reduce cost while maintaining or improving accuracy and precision of the survey. Previous evaluation of this survey provided sampling levels necessary to estimate angling effort with an acceptable level of precision (Fabrizio et al. 1991). Relationships between three northern Lake Michigan sites and four southern Lake Michigan sites were noted in that study, but were not considered reliable due to modest number of years sampled (5) and uncertainty of continued relationships. Sampling of those seven sites was considered a minimum survey design and fell well short of approximate lake-wide estimates. The current goal of the Lake Michigan angler survey is to estimate approximate lake-wide angling effort and harvest.

Linear relationships between sites and time periods have been shown to provide economical benefits in other angler surveys (McNeish and Trial 1991). However, inconsistent relationships existed for boat counts between sites in

statistical district MM-8 and this method was not considered a reasonable alternative to current access count methods for Lake Michigan.

Optimal allocation of clerk effort optimizes clerk effort based on mean and SD of the mean. Since both means and SDs are considered, this method may at times allocate more clerk effort to a site with a lower mean count than adjacent sites. For example, from Table 6 consider June weekend days. Calculated optimal allocation of effort by sample site is: site 160 - 4.6 days, site 166 - 3.8 days, site 156 - 3.3 days, site 164 - 2.8 days, and site 162 - 1.5 days. When sampling is based on mean only (proportional allocation), allocation of clerk effort is different. Proportional allocation of clerk effort by sample site is: site 160 - 4.1 days, site 164 - 4.0 days, site 162 - 2.8 days, site 156 - 2.6 days and site 166 - 2.5 days. Here site 166, which has the lowest mean count (0.1329) but the greatest variability (S^2=0.0738), receives different amounts of sampling depending on whether optimal or proportional allocation is used (3.8 vs. 2.5 clerk days respectively). Thus, optimal allocation of clerk effort would attempt to improve precision at smaller or lesser used, but quite variable, sites.

One of the goals of this study was to improve the accuracy of approximate lake-wide (multiple site or statistical district) angling estimates. Currently, estimates at multiple sites are summed to approximate large area estimates. Sites with greater angling effort represent a greater proportion of lake-wide effort. Improving the accuracy of these sites is essential to improving lake-wide estimates. An inaccurate estimate for a site with more angling effort will influence lake wide estimates more than an inaccurate estimate for a site with less angling effort. Hence, optimal allocation was considered inappropriate for this purpose since sites with smaller sample means and greater variability are allocated more clerk effort.

Proportional allocation of clerk effort has the potential of improving accuracy and precision of more frequently used sites. However, in three statistical districts, allocations based on boat counts differed from allocations based on one or more of the species catch rates. This may be due in part to capacity of boat launch sites. Sites large enough to accommodate many boats typically have greater mean boat counts than smaller sites which accommodate fewer boats. When catch rates were greater at smaller sites with fewer boats counted, inconsistent allocation of clerk effort was suggested.

Fishery differences also confound clerk allocation. For example, in statistical district MM-1 (Table 3) on July weekend days (1994-96 data), angling effort and catch rates of walleye were both greater in section B than in section A. Consequently, more clerk sampling effort was assigned to section B than to section A. Catch rates of salmonines and yellow perch, however, were greater in section A, thus directing more sampling effort to section A.

In summary, allocation of clerk effort based on angling effort and catch rates does not appear to be a satisfactory alternative to the current method of equal allocation.

Total number of Lake Michigan survey clerks may be reduced following a bus route design. However, salary savings of approximately $199.20/d by reduction of two clerks using this method is more than offset by the additional mileage cost. Mileage costs incurred from the bus route design would be over and above present mileage expense. Currently, clerk vehicles are stored at various off site locations, such as district offices or State Police Posts. Each sample day a clerk drives to the storage location in their personal vehicle, picks up the state vehicle and drives to their sample site. Mileage expense from the storage location to the site averages $18.32/d/clerk (G. Rakoczy, personal communication). Therefore, total current daily mileage cost is $183.20 for ten clerks. Reduction to 8 clerks would decrease this daily cost to $146.56. Minimum daily bus route travel expense is an additional $26.30 per clerk or $210.40 for all eight clerks. Thus, minimum daily travel expense for eight clerks is $356.96. Assuming minimum daily travel expense, bus route design would incur an additional $11.20/d over current survey cost.

On days when bus route schedule calls for sampling a site furthest from a clerk's nearest site first, even more mileage expense is incurred. Consider the following examples using

information found in Table 2. Assume mileage is paid from a consistent location for a clerk. In these examples this location is site 1&7 (Note: sites 1 and 7 are considered a single sample site due to their proximate location to one another). If the schedule calls for a clerk to sample sites 1&7, 15 and 18 in that order, the clerk would drive a total of 51.4 miles one way (102.8 miles round trip at a cost of $25.70). If instead, the schedule called for sampling sites 18, 1&7 and 15 in that order, the clerk would drive 51.4 miles to site 18, 51.4 miles back to sites 1&7, 29.4 miles to site 15 and then 29.4 miles back to starting location, for a total of 161.6 miles at a cost of $40.40. In the first example, wait time at each site would be 1.81 h, in the second example wait time at each site would be 1.26 h. In summary, additional mileage costs associated with the bus route method make it impractical. Currently, clerks are remaining at individual sites longer than the bus route method would allow. Reducing time spent at each site would presumably decrease number of angler party interviews collected, resulting in diminished catch estimate precision.

Recommendations

Based on techniques considered in this study, current access site survey methods using equal sampling at all important sites are appropriate and should be continued yearly. In addition, sites of minor importance should be sampled about every three years to update the site-to-site ratios used for approximating lake wide estimates. The updated ratios are recommended because relationships between these sites have not been evaluated since 1985, the accuracy of this method has never been documented, and subtle shifts in fishing pressure and catch may have occurred.

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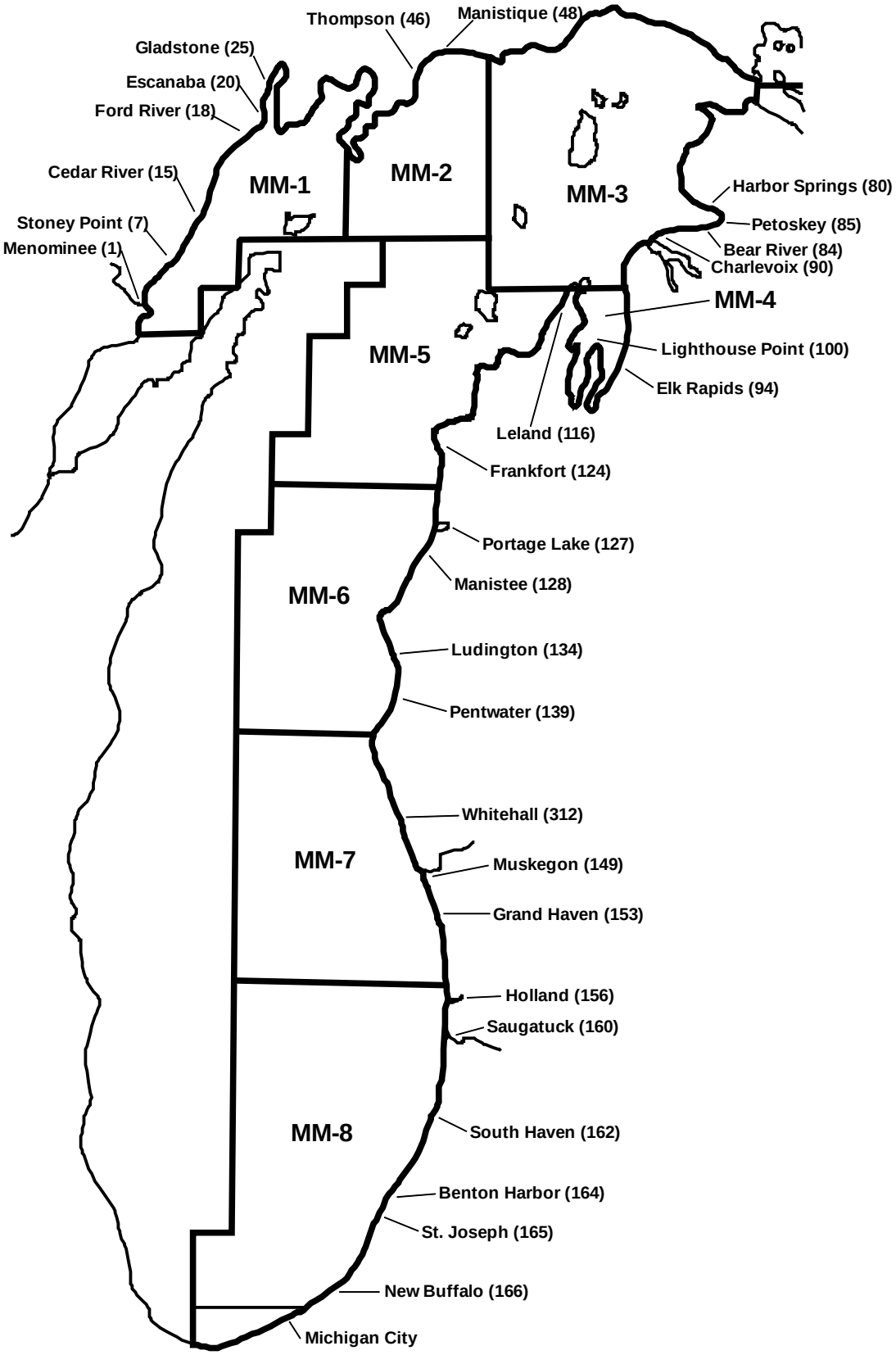

Figure 1.–Statistical districts MM-1 through MM-8 and angler survey sites (site codes in parenthesis) along the Michigan waters of Lake Michigan.

Table 1.–Number of survey clerks per statistical district. Note that MM-5 and MM-6 share a clerk.

Statistical district	Number of clerks
MM-1	2
MM-2	1
MM-3	1
MM-4	1
MM-5	0.5
MM-6	1.5
MM-7	1
MM-8	2

Table 2.–Travel times and distances between Lake Michigan survey sites 1&7 - 48 in statistical districts MM-1 and MM-2.

Sites	Time between sites (min)	Miles between sites
1&7		
	50	29.4
15		
	27	22.0
18		
	25	8.7
20		
	33	12.2
25		
	37	28.4
46		
	8	5.6
48		

Table 3.–Travel times and distances between Lake Michigan survey sites 80&84 - 100 in statistical districts MM-3 and MM-4.

Sites	Time between sites (min)	Miles between sites
80&84		
	65	12.0
85		
	88	39.0
90		
	34	10.8
94&95		
	53	34.2
100		

Table 4.–Travel times and distances between Lake Michigan survey sites 116 - 166 in statistical districts MM-5 through MM-8.

Sites	Time between sites (min)	Miles between sites
116		
	81	51.3
124		
	45	29.5
127		
	24	15.0
128		
	41	30.0
134		
	22	15.5
139		
	38	34.8
312		
	44	19.0
149		
	17	10.0
153		
	30	17.0
156		
	47	21.0
160		
	28	19.0
162		
	41	26.1
164		
	45	31.0
166		

Table 5.–Coefficients of determination for linear relationships between six Lake Michigan sites, 1986-94, in statistical district MM-8. Data values are based on monthly mean interval counts for each year. Monthly means are weighted by count duration. Significant relationships (slope $\neq 0.00$) at $\alpha=0.05$ are noted with an "*". Site codes are shown in Figure 1. Column headers give regression variables (sites) as: independent→dependent.

Month/ day of week	162→156	162→166	164→156	166→156	156→160
April					
weekdays	0.06	0.08	<0.01	0.02	-
weekend days	0.06	0.10	0.01	0.38	-
May					
weekdays	0.46	0.19	0.22	0.19	0.13
weekend days	<0.01	0.13	0.01	0.48	0.01
June					
weekdays	0.17	0.03	0.04	0.07	0.91*
weekend days	0.07	0.16	0.23	0.25	0.02
July					
weekdays	0.26	0.76*	0.72*	0.22	0.32
weekend days	0.91*	0.01	<0.01	0.01	1.00*
August					
weekdays	0.68	0.24	0.14	0.09	0.28
weekend days	0.44	<0.01	0.09	0.09	0.06
September					
weekdays	0.14	0.23	0.09	0.16	0.49
weekend days	<0.01	<0.01	0.08	0.21	0.67
October					
weekdays	0.01	0.02	0.65*	0.32	0.08
weekend days	0.37	0.09	<0.01	0.06	0.01

Table 6.–Optimal allocation of clerk effort based on 1985-95 interval boat counts in Lake Michigan statistical district MM-8. Allocation assumes two clerks working 24 weekdays and 16 weekend days each month. Practical allocation rounds calculated effort to whole days and allows for a minimum of 2 days sampled per site.

	Weekdays					Weekend days				
Month/ Site	Mean Count	S^2	n	Calculated allocation	Practical allocation	Mean Count	S^2	n	Calculated allocation	Practical allocation
April										
156	0.0193	0.0004	24	0.6	2	0.0409	0.0017	17	0.2	2
160	0.0278	0.0024	3	2.1	3	0.1764	0.0171	4	2.8	3
162	0.0877	0.0132	29	15.6	12	0.2040	0.1048	21	8.1	6
164	0.0470	0.0026	40	3.7	4	0.1783	0.0243	31	3.4	3
166	0.0340	0.0014	46	2.0	3	0.0984	0.0162	43	1.5	2
May										
156	0.0546	0.0023	34	2.8	3	0.1217	0.0232	22	1.5	2
160	0.0377	0.0007	9	1.1	2	0.3605	0.0642	9	7.4	7
162	0.0940	0.0207	28	14.6	14	0.1385	0.0289	26	1.9	2
164	0.0531	0.0035	43	3.4	3	0.2044	0.0217	34	2.5	2
166	0.0385	0.0027	46	2.2	2	0.1569	0.0445	45	2.7	3
June										
156	0.0507	0.0028	37	3.7	4	0.1378	0.0497	28	3.3	3
160	0.0787	0.0071	12	9.3	8	0.2139	0.0406	10	4.6	4
162	0.0552	0.0036	42	4.6	5	0.1481	0.0092	25	1.5	2
164	0.0510	0.0029	37	3.8	4	0.2108	0.0154	33	2.8	3
166	0.0364	0.0027	55	2.6	3	0.1329	0.0738	40	3.8	4
July										
156	0.1044	0.0174	36	4.0	4	0.1915	0.0808	26	2.5	2
160	0.2495	0.0344	12	13.5	11	0.3546	0.1647	6	6.6	7
162	0.1144	0.0074	39	2.9	3	0.3057	0.0403	28	2.8	3
164	0.0759	0.0069	38	1.8	3	0.2407	0.0480	36	2.4	2
166	0.0733	0.0067	45	1.8	3	0.1937	0.0327	42	1.6	2
August										
156	0.0915	0.0100	40	4.5	4	0.1022	0.0061	24	0.4	2
160	0.1648	0.0210	9	11.7	11	0.4229	0.2443	8	11.0	8
162	0.0896	0.0108	33	4.6	5	0.1439	0.0203	30	1.1	2
164	0.0747	0.0036	43	2.2	2	0.2330	0.0113	31	1.3	2
166	0.0386	0.0027	51	1.0	2	0.1699	0.0598	42	2.2	2
September										
156	0.0389	0.0087	38	12.3	10	0.1070	0.0118	21	2.2	2
160	0.0167	0.0023	6	2.7	3	0.2000	0.0315	5	6.8	6
162	0.0289	0.0024	37	4.8	5	0.1273	0.0173	25	3.2	3
164	0.0239	0.0020	43	3.6	4	0.1059	0.0190	35	2.8	3
166	0.0090	0.0003	41	0.5	2	0.0799	0.0046	35	1.0	2
October										
156	0.0129	0.0001	32	4.7	5	0.0199	0.0011	21	3.6	3
160	0.0083	0.0003	4	4.2	4	0.0083	0.0008	6	1.3	2
162	0.0119	0.0003	34	6.3	6	0.0245	0.0015	27	5.2	5
164	0.0047	0.0002	36	1.9	2	0.0173	0.0009	34	2.8	3
166	0.0091	0.0006	44	6.9	7	0.0206	0.0007	37	3.1	3

Table 7.–Results of proportional sampling by statistical district in Michigan waters of Lake Michigan. Proportional sampling allocation of effort was done by angling effort (counts), and catch rates of salmonines, walleye and yellow perch.

Statistical district	Satisfactory	Unsatisfactory
1		X
2	X	
3*	X	
4	X	
5*	X	
6		X
7	X	
8		X

* Sampling was 1:1, so either proportional or equal sampling was appropriate.

Table 8.–Proportional sampling schedule for statistical district MM-1 based on instantaneous boat counts and catch rates of salmonines (SAL), yellow perch (YEP), and walleye (WAE). Monthly sample sizes (clerk days) are based on two clerks. Section A is sites 1&7 and 15, and Section B is sites 18, 20 and 25. Either section A or Section B is worked during one clerk day. Sampling schedules are based on 1985-95 data and 1994-96 data.

	Month and section													
	Apr		May		Jun		Jul		Aug		Sep		Oct	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Weekdays														
1985-95														
Boats	4	20	4	20	5	19	7	17	4	20	4	20	4	20
SAL	20	4	20	4	20	4	20	4	20	4	20	4	4	20
YEP	4	20	4	20	20	4	17	7	14	10	10	14	4	20
WAE	20	4	4	20	4	20	4	20	4	20	4	20	12	12
1994-96														
Boats	4	20	4	20	4	20	4	20	4	20	4	20	4	20
SAL	20	4	20	4	20	4	20	4	20	4	20	4	4	20
YEP	4	20	4	20	20	4	20	4	20	4	16	8	4	20
WAE	20	4	4	20	16	8	4	20	4	20	4	20	12	12
Weekend days														
1985-95														
Boats	4	12	4	12	4	12	4	12	4	12	4	12	4	12
SAL	12	4	12	4	12	4	12	4	12	4	12	4	8	8
YEP	4	12	4	12	12	4	10	6	11	5	10	6	4	12
WAE	12	4	4	12	4	12	4	12	4	12	4	12	4	12
1994-96														
Boats	4	12	4	12	4	12	4	12	4	12	4	12	4	12
SAL	12	4	12	4	12	4	12	4	12	4	12	4	8	8
YEP	4	12	4	12	12	4	12	4	11	5	12	4	4	12
WAE	12	4	4	12	9	7	4	12	4	12	4	12	4	12

Table 9.–Proportional sampling schedule for statistical district MM-2 based on instantaneous boat counts and catch rates of salmonines (SAL), yellow perch (YEP), and walleye (WAE). Monthly sample sizes (clerk days) are based on one seasonal clerk. Sampling schedules are based on 1985-89 (last sampled in 1989).

	Month and site number							
	Jul		Aug		Sep		Oct	
	46	48	46	48	46	48	46	48
Weekday								
1985-89								
Boats	4	8	4	8	4	8	4	8
SAL	4	8	4	8	4	8	5	7
YEP	4	8	4	8	6	6	6	6
WAE	4	8	4	8	4	8	6	6
Weekend day								
1985-89								
Boats	2	6	2	6	2	6	2	6
SAL	2	6	2	6	2	6	3	5
YEP	2	6	2	6	4	4	4	4
WAE	2	6	2	6	2	6	4	4

Table 10.–Proportional sampling schedule for statistical district MM-3 based on instantaneous boat counts and catch rates of salmonines (SAL), yellow perch (YEP), and walleye (WAE). Monthly sample sizes (clerk days) are for one clerk. Section A is sites 80 and 85 and Section B is site 90. Either Section A or Section B is worked during one clerk day. Sampling schedules are based on 1985-95 data and 1994-96 data. Periods where data were not available are denoted with "-".

	Month and section													
	Apr		May		Jun		Jul		Aug		Sep		Oct	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Weekday														
1985-95														
Boats	8	4	8	4	7	5	6	6	6	6	6	6	7	5
SAL	6	6	4	8	6	6	5	7	6	6	5	7	7	5
YEP	6	6	8	4	8	4	8	4	8	4	8	4	8	4
WAE	6	6	6	6	6	6	6	6	6	6	6	6	6	6
1994-96														
Boats	-	-	7	5	7	5	6	6	6	6	5	7	-	-
SAL	-	-	3	9	7	5	5	7	6	6	8	4	-	-
YEP	-	-	8	4	6	6	6	6	8	4	8	4	-	-
WAE	-	-	6	6	6	6	6	6	6	6	6	6	-	-
Weekend days														
1985-95														
Boats	6	2	5	3	4	4	3	5	3	5	3	5	4	4
SAL	5	3	4	4	5	3	4	4	4	4	2	6	4	4
YEP	4	4	4	4	6	2	6	2	6	2	6	2	4	4
WAE	4	4	4	4	4	4	2	6	2	6	4	4	4	4
1994-96														
Boats	-	-	5	3	4	4	5	3	4	4	3	5	-	-
SAL	-	-	2	6	4	4	3	5	4	4	5	3	-	-
YEP	-	-	2	6	4	4	4	4	4	4	4	4	-	-
WAE	-	-	4	4	4	4	2	6	4	4	4	4	-	-

Table 11.–Proportional sampling schedule for statistical district MM-4 based on instantaneous boat counts and catch rates of salmonines (SAL), yellow perch (YEP), and walleye (WAE). Monthly sample sizes (clerk days) are for one clerk. Sampling schedules are based on 1985-95 data and 1994-96 data.

	Month and site number													
	Apr		May		Jun		Jul		Aug		Sep		Oct	
	94 & 95	100	94 & 95	100	94 & 95	100	94 & 95	100	94 & 95	100	94 & 95	100	94 & 95	100
Weekdays														
1985-95														
Boats	4	8	4	8	4	8	4	8	4	8	4	8	4	8
SAL	6	6	4	8	4	8	4	8	5	7	6	6	5	7
YEP	4	8	8	4	6	6	6	6	4	8	6	6	4	8
WAE	6	6	6	6	6	6	6	6	6	6	6	6	4	8
1994-96														
Boats	4	8	4	8	4	8	4	8	4	8	4	8	4	8
SAL	4	8	4	8	4	8	4	8	4	8	4	8	4	8
YEP	6	6	6	6	4	8	6	6	4	8	4	8	4	8
WAE	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Weekend days														
1985-95														
Boats	3	5	3	5	3	5	3	5	3	5	3	5	3	5
SAL	4	4	2	6	2	6	4	4	4	4	3	5	2	6
YEP	2	6	2	6	6	2	4	4	2	6	2	6	6	2
WAE	4	4	4	4	4	4	4	4	4	4	4	4	4	4
1994-96														
Boats	3	5	3	5	3	5	3	5	3	5	3	5	3	5
SAL	4	4	2	6	2	6	4	4	2	6	2	6	2	6
YEP	2	6	4	4	2	6	4	4	2	6	2	6	2	6
WAE	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Table 12.–Proportional sampling schedule for statistical district MM-5 based on interval boat counts and catch rates of salmonines (SAL), yellow perch (YEP), and walleye (WAE). Monthly sample sizes (clerk days) are for half-time clerk. Site 116 was last sampled in 1988.

	Month and site number													
	Apr		May		Jun		Jul		Aug		Sep		Oct	
	116	124	116	124	116	124	116	124	116	124	116	124	116	124
Weekdays														
1985-88														
Boats	2	4	2	4	2	4	2	4	2	4	2	4	2	4
SAL	2	4	2	4	2	4	3	3	3	3	2	4	2	4
YEP	3	3	3	3	4	2	4	2	3	3	3	3	3	3
WAE	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Weekend days														
1985-88														
Boats	2	2	2	2	2	2	2	2	2	2	2	2	2	2
SAL	2	2	2	2	2	2	2	2	2	2	2	2	2	2
YEP	2	2	2	2	2	2	2	2	2	2	2	2	2	2
WAE	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Table 13.–Proportional sampling schedule for statistical district MM-6 based on interval boat counts and catch rates of salmonines (SAL), yellow perch (YEP), and walleye (WAE). Monthly sample sizes (clerk days) are for 1.5 clerks. Site 139 was not sampled in 1989-96. Clerk allocations for site 139 during this time period are minimal (2 days) or equal allocation with adjacent sites.

	Month and site number															
	Apr				May				Jun				Jul			
	127	128	134	139	127	128	134	139	127	128	134	139	127	128	134	139
Weekdays																
1985-95																
Boats	2	8	5	3	2	7	6	3	2	6	7	3	2	4	7	5
SAL	4	5	6	3	2	4	4	8	4	4	3	7	5	4	4	5
YEP	2	8	6	2	4	6	6	2	5	2	9	2	2	5	9	2
WAE	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4
1994-96																
Boats	2	9	5	2	2	7	7	2	3	7	6	2	2	6	7	3
SAL	5	5	6	2	3	6	6	3	3	6	6	3	5	5	5	3
YEP	2	2	12	2	2	4	10	2	7	2	7	2	6	2	8	2
WAE	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5	4
Weekend days																
1985-95																
Boats	2	4	4	2	2	3	4	3	2	3	3	4	2	3	4	3
SAL	2	3	4	3	2	3	3	4	3	3	3	3	3	3	3	3
YEP	2	4	4	2	2	2	6	2	2	2	6	2	2	2	4	4
WAE	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1994-96																
Boats	2	5	3	2	3	4	3	2	2	3	5	2	2	4	4	2
SAL	3	3	4	2	4	3	3	2	4	3	3	2	4	3	3	2
YEP	2	2	6	2	2	2	6	2	2	2	6	2	3	2	5	2
WAE	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Table 13.–Continued.

	Month and site number											
	Aug				Sep				Oct.			
	127	128	134	139	127	128	134	139	127	128	134	139
Weekdays												
1985-95												
Boats	2	6	6	4	2	7	7	2	2	8	6	2
SAL	4	4	4	6	6	4	4	4	7	4	4	3
YEP	2	2	12	2	2	10	4	2	2	3	11	2
WAE	4	5	5	4	4	5	5	4	4	5	5	4
1994-96												
Boats	3	8	6	2	4	5	7	2	3	8	5	2
SAL	6	4	5	3	4	5	6	3	5	5	5	3
YEP	5	2	9	2	12	2	2	2	4	5	5	4
WAE	4	5	5	4	4	5	5	4	4	5	5	4
Weekend days												
1985-95												
Boats	2	3	4	3	2	3	3	4	2	4	4	2
SAL	3	3	3	3	3	2	3	4	4	3	3	2
YEP	3	2	5	2	5	2	3	2	2	6	2	2
WAE	3	3	3	3	3	3	3	3	3	3	3	3
1994-96												
Boats	2	3	5	2	2	5	3	2	2	5	3	2
SAL	4	3	3	2	3	4	3	2	3	3	3	3
YEP	5	2	3	2	6	2	2	2	3	3	3	3
WAE	3	3	3	3	6	2	2	2	3	3	3	3

Table 14.–Proportional sampling schedule for statistical district MM-7 based on interval boat counts and catch rates of salmonines (SAL), yellow perch (YEP), and walleye (WAE). Monthly sample sizes (clerk days) are for one clerk. Site 312 was rarely sampled.

	Month and site number											
	Apr			May			Jun			Jul		
	312	149	153	312	149	153	312	149	153	312	149	153
Weekdays												
1985-95												
Boats	2	7	3	2	5	5	4	4	4	2	4	6
SAL	2	3	7	2	4	6	2	4	6	2	4	6
YEP	2	8	2	2	8	2	2	7	3	2	6	4
WAE	4	4	4	4	4	4	4	4	4	2	8	2
1994-96												
Boats	2	7	3	2	6	4	2	5	5	2	6	4
SAL	4	4	4	2	5	5	2	5	5	2	3	7
YEP	2	8	2	2	8	2	2	7	3	2	7	3
WAE	4	4	4	4	4	4	4	4	4	2	8	2
Weekend days												
1985-95												
Boats	2	3	3	2	3	3	2	3	3	2	3	3
SAL	2	2	4	2	3	3	2	3	3	2	3	3
YEP	2	4	2	2	4	2	2	4	2	2	3	3
WAE	2	4	2	2	3	3	2	3	3	2	4	2
1994-96												
Boats	2	3	3	2	3	3	2	3	3	2	3	3
SAL	2	2	4	2	2	4	2	3	3	2	2	4
YEP	2	4	2	2	4	2	2	3	3	2	4	2
WAE	2	4	2	2	3	3	2	3	3	2	4	2

Table 14.–Continued.

	Month and site number								
	Aug			Sep			Oct		
	312	149	153	312	149	153	312	149	153
Weekdays									
1985-95									
Boats	2	6	4	2	6	4	2	6	4
SAL	2	4	6	2	4	6	2	4	6
YEP	2	7	3	2	3	7	2	7	3
WAE	2	8	2	4	4	4	4	4	4
1994-96									
Boats	2	6	4	2	6	4	2	6	4
SAL	2	5	5	2	6	4	2	5	5
YEP	2	5	5	2	3	7	2	8	2
WAE	2	2	8	4	4	4	4	4	4
Weekend day									
1985-95									
Boats	2	2	4	2	3	3	2	3	3
SAL	2	3	3	2	3	3	2	2	4
YEP	2	4	2	2	4	2	2	2	4
WAE	2	4	2	2	3	3	2	3	3
1994-96									
Boats	2	3	3	2	3	3	2	3	3
SAL	2	2	4	2	3	3	2	3	3
YEP	2	4	2	2	4	2	2	3	3
WAE	2	4	2	2	3	3	2	3	3

Table 15.–Proportional sampling schedule for statistical district MM-8 based on interval boat counts and catch rates of salmonines (SAL), yellow perch (YEP), and walleye (WAE). Monthly sample sizes (clerk days) are for two clerks. Site 160 was not sampled 1989-96. Clerk allocations for site 160 during this time period are minimal (2 days) or equal allocation with adjacent sites.

	Month and site number																			
	Apr					May					Jun					Jul				
	156	160	162	164	166	156	160	162	164	166	156	160	162	164	166	156	160	162	164	166
Weekdays																				
1985-95																				
Boats	2	3	10	5	4	5	3	8	5	3	4	7	5	5	3	4	10	4	3	3
SAL	3	2	3	7	9	6	5	2	5	6	6	2	3	6	7	9	3	3	3	6
YEP	2	2	16	2	2	2	2	16	2	2	3	3	8	6	4	2	3	8	7	4
WAE	2	2	2	2	16	2	9	2	9	2	2	9	2	9	2	2	12	2	6	2
1994-96																				
Boats	2	2	14	4	2	4	2	11	4	3	5	2	9	5	3	6	2	7	6	3
SAL	4	2	3	5	10	8	2	2	5	7	7	2	3	6	6	8	2	4	5	5
YEP	2	2	16	2	2	2	2	16	2	2	2	2	12	3	5	3	2	8	5	6
WAE	5	4	5	5	5	5	4	5	5	5	5	4	5	5	5	5	4	5	5	5
Weekend days																				
1985-95																				
Boats	2	4	4	4	4	2	6	2	3	3	3	4	3	3	3	2	4	4	3	3
SAL	3	2	2	4	5	4	3	2	3	4	6	2	2	2	4	6	2	2	3	3
YEP	2	2	8	2	2	2	2	8	2	2	2	3	5	4	2	3	2	4	4	3
WAE	2	8	2	2	2	2	7	3	2	2	2	4	4	4	2	2	2	4	6	2
1994-96																				
Boats	2	2	7	3	2	3	2	5	4	2	5	2	4	3	2	3	2	6	3	2
SAL	2	2	2	4	6	5	2	2	3	4	4	2	2	4	4	7	2	2	3	2
YEP	2	2	8	2	2	2	2	8	2	2	2	2	8	2	2	3	2	5	2	4
WAE	3	3	4	3	3	3	3	4	3	3	2	2	8	2	2	2	2	8	2	2

Table 15.–Continued.

	Month and site number														
	Aug					Sep					Oct				
	156	160	162	164	166	156	160	162	164	166	156	160	162	164	166
Weekdays															
1985-95															
Boats	5	8	5	4	2	8	3	6	5	2	7	4	6	2	5
SAL	6	5	4	5	4	10	4	4	3	3	6	4	4	4	6
YEP	5	2	6	5	6	4	2	6	6	6	2	2	10	7	3
WAE	5	4	5	5	5	4	8	4	4	4	5	4	5	5	5
1994-96															
Boats	6	2	8	6	2	6	2	9	4	3	4	2	9	4	5
SAL	11	2	4	3	4	10	2	4	4	4	8	2	2	7	5
YEP	4	2	6	6	6	5	2	13	2	2	2	2	8	9	3
WAE	5	4	5	5	5	5	4	5	5	5	5	4	5	5	5
Weekend days															
1985-95															
Boats	2	6	2	3	3	3	4	3	3	3	3	2	4	3	4
SAL	4	3	4	2	3	4	5	3	2	2	4	2	2	2	6
YEP	2	2	4	3	5	3	2	5	3	3	2	2	4	6	2
WAE	2	6	3	3	2	2	5	2	5	2	3	3	3	3	4
1994-96															
Boats	3	2	5	4	2	4	2	3	5	2	3	2	5	3	3
SAL	5	2	4	3	2	6	2	2	4	2	4	3	3	3	3
YEP	3	2	5	2	4	2	2	7	2	3	4	2	6	2	2
WAE	3	3	4	3	3	4	3	3	3	3	3	3	4	3	3

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James S. Diana, Editor
Gerald P. Rakoczy, Editorial Board Reviewer
Alan D. Sutton, Graphics
Barbara A. Diana, Word Processor