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Abstract.–Estimates of sport fishery angling harvest, catch and release, and effort were made using direct contact angler surveys for 50 inland lakes or rivers between spring 1993 and spring 1999. Purposes for angler creel surveys varied: 28% evaluated fish stockings, 24% estimated catch or harvest of a particular species of interest, 22% characterized the fishery, 22% both characterized the fishery and determined angler residency, and 4% estimated angling effort only. Thirty-five separate sites were surveyed, 30 lakes and 5 rivers. Some sites were sampled in multiple years and 1-14 surveys were conducted each year. Multiple fishing modes were sampled for a total of 69 mode-site surveys. Of these mode-specific surveys (MSS), 72% used indirect counts of anglers and 28% used direct counts. Most MSS counts (59%) used a roving count method, 22% used the progressive method, 16% used the proportional method, and 3% used aerial surveys. Most MSS indirect counts were of boats (40%). Trailer-vehicle counts represented 25%, and counts of ice shanties 8%, of MSS. Three percent of MSS collected counts only; catch or harvest was not estimated. Four interview types were collected: access angler party interviews (42%), voluntary-access party interviews (27%), roving party interviews (16%), and roving individual angler interviews (12%). Count and interview data were collected by Fisheries Division employees or employees of cooperating agencies at some locations, and by volunteers at others. Sources of data and specific methodology, or appropriate references, are given for each reported survey to allow duplication at a later date and to clarify limitations of each. In addition to harvest, catch-and-release, and effort estimates, many surveys collected angler residency, bait type used, targeted effort, number of fishing trips taken per day, and angler gender. Where possible, these data were summarized by month and season. To more thoroughly compile existing Michigan sport angler survey estimates, reference sources for additional surveys are given.

Introduction

Angler creel surveys are conducted on Michigan waters to estimate angling effort and catch or harvest by species. These surveys may be conducted for specific purposes such as to: characterize the fishery (Herman 1989), evaluate fish stocking (Wagner et al. 1994), or evaluate fishing regulations (Lockwood et al. 1995). Different goals lead to different survey frequencies. For example, Fisheries Division has surveyed selected Great Lake ports annually since 1985 to measure long-term trends in angling effort and harvest (e.g., Rakoczy and Svoboda 1995b). These surveys provide essential information necessary to manage Great Lake stocks (e.g., Schorfhaar and Schneeberger 1997). However, surveys of smaller inland fisheries vary in frequency, purpose, and location (e.g., Ryckman and Lockwood 1985).

Angler surveys require consistent and appropriate methodology to provide comparable estimates that minimize bias. However angler surveys in Michigan date back to the 1930s (Tait 1953) and while methods have been summarized periodically (e.g., Guthrie et al. 1991; Pollock et al. 1994), they continue to be refined. For example, numerous changes in estimation methodology have occurred since 1993, and appropriate catch-rate estimators used with access and roving interviews have only recently been recognized (Jones et al. 1995; Lockwood 1997). Similarly, improvements in variance estimators have recently been documented and implemented in Michigan creel surveys (Lockwood et al. 1999).

The surveys of inland lake and river anglers described in this report varied in purpose, methodology, and duration. The purpose of this report was to present results from each survey and to provide the reader with an appropriate description of site locations and methods, as well as a summary of sources of error and correction methods. Specific survey estimates are presented in chapter format within the accompanying appendices. Each chapter describes location of a survey, and sub-sites or sampling units used. Starting and ending dates of the survey are also given, as are the types of interview or count data collected. Survey results are in alphabetical order by location and date of survey. Lake surveys are followed by river surveys.

Methods

With two exceptions, each survey consisted of counts of fishing activity (e.g., number of anglers or boats) and interviews of anglers (e.g., information on catch, trip effort, etc.). These basic data were used to estimate angling effort, and number of fish caught (harvested or released) per hour, month, or season. For the two exceptions (Stanley Lake 1993 and Hagerman Lake 1994), only counts of fishing activity were gathered and used to estimate angling effort.

Angler creel surveys given in the appendix are described by type of count and interview data collected, and follow terms used by Pollock et al. (1997). A survey may, for example, be referred to as an aerial-roving design. In this example, counts were made from an aircraft and anglers were interviewed as they fished. Similarly, a roving-access design indicates that a ground-based clerk counted angling activity and interviewed anglers at access points after they completed their fishing trips.

Initiation of the surveys reported here follow the process described in Lockwood (2000). That is, field managers determined the need for a survey, and secured necessary funding and equipment; this study provided appropriate sampling design, data processing, calculation and reporting of estimates.

Common and binomial names for species reported here are given in Table 1. In some cases numerous species were included in a broad generic term (e.g., panfish). When such terms were used in appendices, species included within that group were listed in a footnote.

Unless otherwise noted, all estimates were given with 2 standard errors. These error bounds provide statistical significance of 75% to 95% depending on sample size (Dixon and Massey 1957:292).

Counts of angling effort

Counts noted here were "aerial", "roving", "progressive", or "proportional". While these count types have similarities, aerial counts are instantaneous counts made from an aircraft; roving counts are instantaneous counts made from one or more vantage points by a ground-based clerk; progressive counts are counts made by a clerk progressing through an area; and proportional counts are instantaneous counts made at a non-random time. A true instantaneous count, whether aerial or roving, is a count of angling activity during an instant in time. An example of an instantaneous aerial count is when a plane flies over a pier and counts all anglers fishing from the pier. Examples of instantaneous roving counts are counts made by a clerk of all trailers in one or multiple parking lots, or counts of boats made from one or multiple vantage points along a lake. Progressive counts are counts that take some measurable length of time. Typically, a clerk progresses through an area enumerating anglers encountered. For example, a clerk canoeing through a stretch of river counts anglers as they are passed. Specifically, when a clerk travels to multiple sites within a particular survey area (e.g., lake) and the order or starting point is randomized, the count type is referred to as progressive. When a clerk travels to multiple unique survey sites (e.g., different lakes), the count type is referred to as roving.

Parker (1956) and McNeish and Trial (1991) described an additional count method referred to here as the proportional count method. With this method, the proportion of angling activity at a given hour from the interview data set expands instantaneous counts of angling activity. If for example, 10% of anglers interviewed were present at some hour, a count made at that hour is assumed to represent 10% of angling activity for the daily period sampled. Since access interviews are required, surveys using this method are referred to as proportional-access or proportional-voluntary.

The same techniques are used to estimate angling effort from aerial, roving, and progressive counts (Lockwood et al. 1999); these are treated as counts made at an instant in time. However, sampling designs differ. Aerial and roving counts that take no appreciable length of time follow a random design (in terms of day and time of count) but by definition, with a non-random start location (assuming multiple count locations). Progressive counts use a random count order and count direction (Hoenig et al. 1993). Progressive counts noted in this current report fall into two categories: 1) progressive counts made from a vehicle, and 2) progressive counts made while canoeing a river. For progressive counts made from a vehicle, order and direction of count were both randomized. For progressive counts made while canoeing, only order of sections counted was randomized since river shape and current constrain direction.

Interviews and catch rate estimation

Catch rates are determined via interviews, and 3 types were collected and reported here: access, roving, and voluntary. Access interviews, also referred to as complete-trip interviews, contain information from one fishing trip, either per angler or per angling party. Roving interviews, also referred to as incomplete-trip interviews, are taken before a fishing trip was finished. Roving interviews collected prior to 1996 were roving party interviews. That is, catch was pooled for all anglers in a party. Lockwood (1997) showed there was potential for bias when roving interviews were recorded by angling party. Subsequent roving interviews, beginning in 1996, were collected by angler (note: anglers per party were also recorded for estimation of angler effort from boat effort). Voluntary interviews are usually complete-trip interviews, but the angler voluntarily reports the information. Voluntary information was reported on forms given to anglers or on forms anglers picked up at specific locations.

Until 1996, Michigan catch rates from inland creel surveys were estimated using the mean-of-ratios estimator, $\bar{R}$, regardless of interview type:

$$\bar{R} = \frac{\sum_{f=1}^{k} c_f / h_f}{k}, \tag{1}$$

where c_f is the total catch of party f which collectively fished h_f hours with k parties interviewed. Surveys conducted since then have used the ratio-of-means estimator, $\hat{R}$, for access interviews:

$$\hat{R} = \frac{\sum_{f=1}^{k} c_f}{\sum_{f=1}^{k} h_f}, \tag{2}$$

and the mean-of-ratios estimator, $\bar{R}$, for roving angler interviews collected by angler:

$$\bar{R} = \frac{\sum_{f'=1}^{k'} c_{f'} / h_{f'}}{k'}, \tag{3}$$

where $c_{f'}$ is the total catch of angler f', with $h_{f'}$ hours fished, and k' anglers interviewed.

Effort and catch estimators

Methods for estimating angling effort and catch from traditional access, roving, or progressive data were given in Lockwood et al. (1999). Estimated effort, catch, or harvest for surveys prior to 1996 were presented in Appendix 1 of Lockwood et al. (1999). Surveys completed in 1996 used the methods given in Appendix 1 of Lockwood et al. (1999) to estimate effort and the appropriate catch rate estimator (found in the main text of Lockwood et al. 1999) to estimate catch rate and catch. More recent surveys have followed methods presented in the main text of Lockwood et al. (1999). Regardless of method, references to the appropriate methods are given in each appendix chapter.

To estimate effort using the proportional count method, proportion (P_j) of anglers at hour j in an access interview data set spanning m hours was calculated as:

$$P_j = \frac{a_j}{\sum_{j=1}^{m} a_j}, \tag{4}$$

where a_j is the number of anglers present at hour j. Variance was estimated as (Cochran 1977:60):

$$V\hat{a}r(P_j) = \frac{P_j Q_j}{m}, \tag{5}$$

where Q_j is $1\text{-}P_j$. Estimated effort, E_i, based on count C_i at time i then was:

$$E_i = \frac{FC_i}{P_i}, \tag{6}$$

where F is the total number of hours within the sample period. Within-day variance was estimated as (Freese 1962:17):

$$V\hat{a}r(E_i) = E_i^2 \left[\frac{V\hat{a}r(P_i)}{P_i^2} \right]. \tag{7}$$

Mean estimated effort from n counts then was:

$$\hat{E} = \frac{\sum_{i=1}^{n} E_i}{n}, \tag{8}$$

with estimated variance (Cochran 1977:277):

$$V\hat{a}r(\hat{E}) = \left(1 - \frac{n}{D}\right) \left(\frac{\sum_{i=1}^{n} \left(E_i - \hat{E}\right)^2}{n(n-1)} \right) + \left(\frac{1}{Dn}\right) \left(\sum_{i=1}^{n} V\hat{a}r\left(E_i\right) \right), \tag{9}$$

for some period of D days.

Demographics

In addition to fishing effort, catch, and harvest; anglers were often queried as to residency, bait type (in some instances fishing method was also recorded), species targeted, number of fishing trips taken per day, and gender. When any of these data were collected, results were given in appendices following effort and catch estimates. These demographic results were reported as percentages and include error bounds (EB). Error bounds were calculated after equation (5) as:

$$EB = 2 \bullet 100 \bullet \sqrt{\frac{(p \cdot q)}{k'}}, \qquad (10)$$

where p is the fraction of anglers within some category, q is 1-p, and k' the total number of anglers interviewed (Cochran 1977:60).

Description of inland surveys

Fifty angler surveys were conducted at 35 different locations, between spring 1993 and spring 1999. Most sites were in the western end of the Upper Peninsula, the central Upper Peninsula, and the southern edge of the Lower Peninsula (Figure 1). Forty-two surveys were conducted on inland lakes and 8 surveys were conducted on inland rivers. Number of surveys conducted each year varied from 1-14 (1-12 for lakes and 0-3 for rivers).

Angler surveys were conducted for a variety of reasons. Twenty-eight percent of surveys evaluated fish stocking, 24% evaluated catch or harvest of specific species of interest, 22% characterized the fishery and determined angler residency, 22% characterized the fishery, and 4% estimated angling effort only.

These 50 angler surveys sampled 69 mode-site fisheries (Table 2). Most (72%) of these 69 mode-specific surveys used counts of units representing anglers (e.g., boats), with the remaining 28% being direct counts of anglers. Boats were the most frequent unit counted (40%), followed by direct counts of anglers (28%), trailers-vehicles (25%), and shanties (7%). Roving counts were most frequently used (59%), followed by progressive (22%), proportional (16%), and aerial (3%) counts.

Access interviews by angling party were most often used (42%), followed by voluntary party interviews (27%), roving party interviews (16%), and roving individual angler interviews (12%). Three percent of mode specific surveys did not collect interviews. Access party boating interviews were the dominant interview type (22%), with 14% voluntary party trailer-vehicle interviews, and 13% access party angler interviews. Lesser percentages of interview types were used for the remaining fishing modes sampled.

Discussion

Surveys of inland anglers conducted between 1993 and 1999 used a wide variety of creel-survey techniques. Each method was appropriate for a local purpose, and the range of these reflects the diversity of inland fisheries and management questions. Some surveys evaluated management actions (such as stocking), while others documented the fishery and added to the basin unit managers' knowledge of fisheries within their management units. As such, comparisons among lakes are difficult, and global generalization is not possible and should not be expected.

Creel surveys are planned to follow a specific design. However, ease or difficulty of data collection may require a change in the data types collected after a study has begun. For example, a survey may be designed to collect access interviews. But if, after a survey begins, the clerk discovers that anglers are difficult to contact after they complete their trips and roving interviews are easily collected, then both interview types may be collected. In such situations, the predominance of one interview type or the other is determined and the appropriate catch rate estimator for that interview type is used on all data. An exception to that procedure was noted in the Gogebic Lake, 1999 appendix. There, similar numbers of roving and access interviews were collected within many strata and weighted averages were calculated using the appropriate catch rate estimator.

Calendar year 1996 served as a transition period for estimation methods. Bias associated with catch rate estimators was removed in surveys conducted in 1996 and subsequent years. Similarly, accuracy of effort variance estimators improved with the 1997 surveys.

Catch for years prior to 1996 may have been overestimated. For catch rate estimates from specific sites, modes, and time periods, Lockwood (1997) showed that when the mean-of-ratios estimator is used with access interviews, catch rate is overestimated approximately 60% of the time and underestimated approximately 40% of the time. Overestimate or underestimate varied from 0.36-285.50%. However, seasonal point estimates are the summation of time period, mode, and site stratification estimates. Summation of these strata estimates should result in a moderate overestimation.

Variability of estimated effort for years prior to 1997 may have been underestimated. Lockwood et al. (1999) provided variance equations for angling effort that more appropriately account for between-day variation and sample-size variation (variation due to number of days sampled within a time period). Recalculation of Great Lakes creel survey estimates showed that effort variability, using methods found in Appendix 1 of Lockwood et al. (1999), is underestimated (Jim Bence, MSU-PERM).

Evaluations by Lockwood (1999) and McNeish and Trial (1991) showed that the proportional method produces a reliable estimate of angling effort. McNeish and Trial (1991) found within-day variability, estimated by equation (5), to be minor (0.02% to 0.08% of total variation) relative to between-day variation. Consequently, they chose to ignore within-day variation. Lockwood et al. (2000) using bootstrapping techniques to estimate within-day variation, also found within-day variation to be minor (0.10% to 7.78% of total variation). Nevertheless, within-day variation was estimated for surveys reported here.

Nineteen mode-site survey estimates relied on voluntary information and must be viewed with caution. Specifically, the probability of an individual angler being interviewed is unknown and cannot be approximated. Therefore, while voluntary interviews can provide relative fishery estimates, concerns over accuracy remain (Pollock et al. 1994).

Because of variation in purpose and methods; accurate, specific descriptions of individual surveys is essential. Such information is vital for comparisons with future surveys and replication of methods. Continued evaluation of angler survey methods and development of new methods remains crucial to future angler surveys, and accurate reporting is needed to estimate conversion factors. Providing accurate and precise estimates of angling effort, catch, and harvest are also essential to sound management practices and research conclusions, and is imperative to develop agreements with constituent groups.

In addition to current inland angler surveys, references for inland angler surveys conducted since the 1970’s are presented in Table 3. For older surveys see Schneider and Lockwood (1979). (For documentation purposes, Great Lakes angler survey references are listed in Table 4.)

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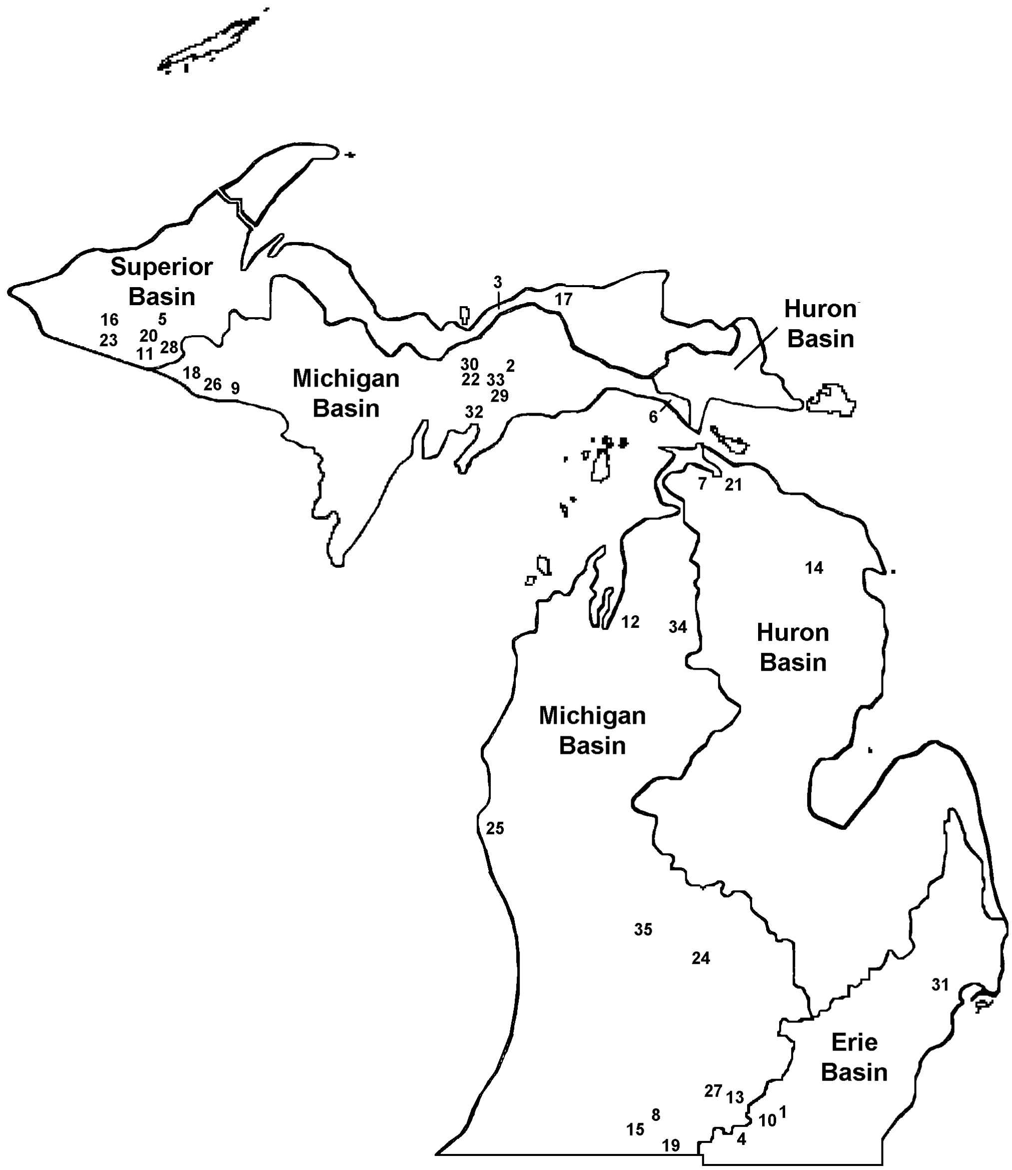

Figure 1.–Location of inland angler surveys conducted 1993-99, within Great Lake basin boundaries. Lakes are listed first, followed by rivers.

Number	Lake	Number	Lake	Number	Lake	Number	River
1	Allen L.	11	Duck L.	21	Mullett L.	31	Clinton R.
2	Bass L.	12	Elk L.	22	Petes L.	32	Fishdam R.
3	Beaver L.	13	Farwell L.	23	Pomeroy L.	33	Indian R.
4	Bird L.	14	Fletcher F.	24	Sessions L.	34	Manistee R.
5	Bond Falls F.	15	Gilead L.	25	Silver L.	35	Rogue R.
6	Brevoort L.	16	Gogebic L.	26	Stanley L.		
7	Burt L.	17	Grand Sable L.	27	Swains L.		
8	Cary L.	18	Hagerman L.	28	Tamarack L.		
9	Chicagon L.	19	Lavine L.	29	Thunder L.		
10	Deep L.	20	Marion L.	30	Wedge L.		

Table 1.–Common and scientific names of fish noted in this report.

Common name	Scientific name
Bass	*Micropterus spp.*
Black crappie	*Pomoxis nigromaculatus*
Bluegill	*Lepomis macrochirus*
Brook trout	*Salvelinus fontinalis*
Brown bullhead	*Ictalurus nebulosus*
Brown trout	*Salmo trutta*
Bullhead	*Ictalurus spp.*
Carp	*Cyprinus carpio*
Channel catfish	*Ictalurus punctatus*
Crappie	*Pomoxis spp.*
Lake herring or cisco	*Coregonus artedii*
Lake trout	*Salvelinus namaycush*
Largemouth bass	*Micropterus salmoides*
Muskellunge	*Esox masquinongy*
Northern pike	*Esox lucius*
Pumpkinseed	*Lepomis gibbosus*
Rainbow trout, steelhead	*Oncorhynchus mykiss*
Rock bass	*Ambloplites rupestris*
Smallmouth bass	*Micropterus dolomieui*
Sucker	*Catostomus spp.*
Sunfish	*Lepomis spp.*
Walleye	*Stizostediom vitreum vitreum*
White bass	*Morone chrysops*
White sucker	*Catostomus commersoni*
Yellow perch	*Perca flavescens*

Table 2.–Number of count and interview types. Since multiple fishing modes were sampled on some surveys (e.g., boat angling and shore angling), total from this table will be greater than the number of angler survey chapters presented in this report.

Count type/ mode	Interviews					
	Roving		Access	Voluntary		Mode
	Party	Angler	Party	Party	None	Totals
Roving						
Boat	1	-	14	3	2	20
Trailer-Vehicle	-	-	2	2	-	4
Shanty	3	-	1	-	-	4
Angler	3	-	8	2	-	13
Progressive						
Boat	2	2	1	-	-	5
Trailer-Vehicle	-	1	2	-	-	3
Shanty	-	1	-	-	-	1
Angler	2	3	1	-	-	6
Aerial						
Boat	-	1	-	1	-	2
Proportional						
Boat	-	-	-	1	-	1
Trailer-Vehicle	-	-	-	10	-	10
Interview Totals	11	8	29	19	2	69

Table 3.–Additional sources containing angler creel survey estimates for Michigan inland lakes and rivers. See also Schneider and Lockwood (1979).

Water	County	Years	Reference
Inland lakes			
Anderson	Marquette	1983-84	Wagner (1988)
Bankson	Van Buren	1985-86	Duffy (1991)
Gogebic	Gogebic	1940-41, 1947, 1976-77	Norcross (1986)
Big Shag	Marquette	1983-84	Wagner (1988)
Cass	Oakland	1986	Waybrant and Thomas (1988)
Cass	Oakland	1988	Schneider et al. (1989)
Chicago	Delta	1983-84	Wagner (1988)
Devils	Lenawee	1987	Herman (1989)
East	Schoolcraft	1983-84	Wagner (1988)
Gull	Kalamazoo	1986-87	Dexter (1991)
Kent	Oakland	1987	Thomas (1990)
Kent	Oakland	1988	Schneider et al. (1989)
Kent	Oakland	1980	Goudy (1981)
Lansing	Ingham	1987	Herman (1989)
Maceday-Lotus	Oakland	1986	Waybrant and Thomas (1988)
Many	Many	1975-82	Ryckman and Lockwood (1985)
Many	Gogebic	1989, 1991	Miller (1992)
Orchard	Oakland	1986	Waybrant and Thomas (1988)
Pontiac	Oakland	1980	Goudy (1981)
Stager	Iron	1983-84	Wagner (1988)
Tepee	Iron	1983-84	Wagner (1988)
Vineyard	Jackson	1987	Herman (1989)
Wakeley	Crawford	1987, 1990, 1998	Schneider (In press)
White	Oakland	1987	Thomas (1990)
Whitmore	Washtenaw	1980	Goudy (1981)

Table 3.–continued.

Water	County	Years	Reference
Rivers			
Au Sable	Crawford	1976, 1980-83	Clark and Alexander (1984)
Au Sable, North Branch	Crawford	1974-82, 1985-90	Clark and Alexander (1992)
Au Sable, North Branch	Crawford	1976, 1980-83	Clark and Alexander (1984)
Au Sable, South Branch	Crawford	1974-82, 1985-90	Clark and Alexander (1992)
Carp	Marquette	1984-87	Peck (1992)
Chocolay	Marquette	1984-87	Peck (1992)
Dead	Marquette	1984-87	Peck (1992)
Escanaba, East Branch	Marquette	1988-89, 1990-92	Wagner et al. (1994)
Escanaba, West Branch	Dickinson	1988-89, 1990-92	Wagner et al. (1994)
Grand	Ingham	1987	Herman (1989)
Huron	Oakland	1975, 1987	Ostaszewski (1990)
Huron	Washtenaw	1985-88, 1990-93	Lockwood et al. (1995)
Iron	Iron	1988-89, 1990-92	Wagner et al. (1994)
Ontonagon, Middle Branch	Gogebic	1988-89, 1990-92	Wagner et al. (1994)

Table 4.–Additional sources containing angler creel survey estimates for Michigan Great Lakes waters.

Water	County	Years	Reference
Les Cheneaux Islands, Lake Huron	Mackinac	1986	Lucchesi (1988)
Saginaw Bay, Lake Huron	Many	1983-84	Ryckman (1986)
Superior (near Marquette)	Marquette	1984-87	Peck (1992)
Superior (near Isle Royale)	Keweenaw	1998	Lockwood et al. (2000)
Great Lakes	Many	1985-86	Rakoczy and Lockwood (1988)
Great Lakes	Many	1986-87	Rakoczy and Rogers (1987)
Great Lakes	Many	1987-88	Rakcozy and Rogers (1988)
Great Lakes	Many	1988-89	Rakoczy and Rogers (1990)
Great Lakes	Many	1989	Rakoczy and Rogers (1991a)
Great Lakes	Many	1989-90	Rakoczy and Rogers (1991c)
Great Lakes	Many	1990	Rakoczy and Rogers (1991b)
Great Lakes	Many	1990-91	Rakoczy (1992b)
Great Lakes	Many	1991	Rakoczy (1992a)
Great Lakes	Many	1991-92	Rakoczy (1992c)
Great Lakes	Many	1992	Rakoczy and Svoboda (1993)
Great Lakes	Many	1992-93	Rakoczy and Svoboda (1994b)
Great Lakes	Many	1993	Rakoczy and Svoboda (1994a)
Great Lakes	Many	1993-94	Rakoczy and Svoboda (1995b)
Great Lakes	Many	1994	Rakoczy and Svoboda (1995a)

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