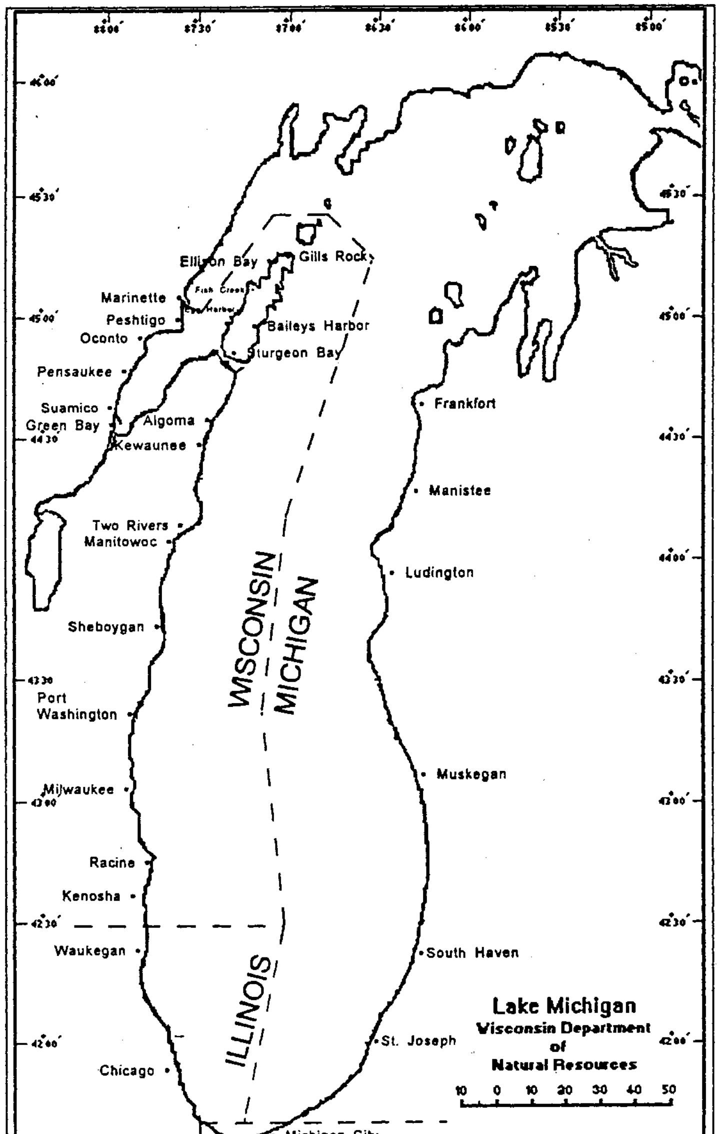
Lake Michigan Creel Survey Methods



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Version 2 07/20/95

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CREEL SURVEY OF THE ILLINOIS WATERS OF LAKE MICHIGAN

Geographic area

The geographic setting of this survey is the **Illinois shoreline of Lake Michigan**. The area under the jurisdiction of Illinois includes **63 miles** of Lake Michigan shoreline. This area is highly developed and heavily industrialized. Chicago covers roughly one-third of the shoreline, and a series of smaller cities cover almost all of the remainder. This section of Lake Michigan lacks significant tributary streams. The slope of the near-shore lake bottom becomes progressively steeper as one moves from south to north, a geographic feature that influences the distribution and success of sport fishing. The Chicago shoreline consists of a series of parks and small harbors with access from Lake Shore Drive. There are also three power plants along the shoreline: the Zion plant which is nuclear powered, Waukegan which is coal powered and Winnetka which is oil powered. The Waukegan and Winnetka cooling water outflows are accessible to pedestrian anglers but the Zion outflow is accessible only by boat.

Creel sampling dates

The core of this survey, with the most intense sampling, is from **April 1 to September 30**. In the first few years of this study the survey was year round with less intense sampling from October 1 to March 31. In later years the **legal snagging season was sampled from Oct. 1 to Nov. 15** and in one year the early spring coho fishery was sampled during the month of March. In fact, this year (1995) the early spring fishery and the legal snagging fishery will be sampled in addition to the core six month survey.

Table 1. Summary of the Illinois Lake Michigan creel schedule since 1985.

Year	Core creel	Snagging	Winter	Smelt	Helicopter	Early Spring
1985	4/1 - 10/27	10/1 - 12/31	1/1/86 - 3/31	4/1 - 4/30	3 flights	N/A
1986	4/1 - 10/5	10/1 - 11/15	10/1 - 3/31/87	4/1 - 5/1	3 flights	N/A
1987	4/1 - 10/3	10/1 - 12/31	10/1 - 3/31/88	4/1 - 4/16	7 flights	N/A
1988	4/1 - 9/30	10/1 - 12/31	10/1 - 3/31/89	4/1 - 5/15	7 flights	N/A
1989	4/1 - 9/30	no	no	no	1 flight	N/A
1990	4/1 - 9/30	10/1 - 11/18	no	no	2 flights	3/17 - 3/24
1991	4/1 - 9/30	10/1 - 11/10	no	no	none	no
1992	4/1 - 9/30	10/1 - 11/15	no	no	4 flights	no
1993	4/1 - 9/30	10/1 - 10/15	no	no	2 flights	no
1994	4/1 - 9/30	10/1 - 11/15	no	no	4 flights	no
1995	4/1 - 9/30	10/1 - 11/15	no	no	4 flights scheduled	3/1 - 3/31

Fishery types

The present survey **samples launched boat and pedestrian (pier, shore, and harbor) anglers directly and extrapolates launched boat effort and harvest to moored boats.** Special anglers such as **snaggers** are also sampled. In previous surveys, ice and smelt anglers have also been sampled. Charter boats are surveyed separately through catch reports to the IDOC.

Creel survey sampling design

The sampling design used in this survey is a **modified stratified random sampling design**. The design is not truly random as the coverage per week, per site is fixed. The time of day that an individual site is visited by a creel clerk is fixed. Twenty-seven major fishing areas have been identified along the Illinois shoreline which, through counts using helicopter flights, account for 100% of the launched boats and 97% of the pedestrian anglers. Eight pedestrian sites and four boat ramps were selected from the 27 sites (accounting for 79% of the pedestrian anglers and 62% of the launched boats) to be sampled twice a week, once on a work week day and once during the weekend. The twelve sites have been grouped into four clusters consisting of two pedestrian sites and one launched boat site all in relatively close proximity to each other. One cluster covers Winthrop Harbor and Waukegan, one covers the north side of Chicago, another covers central Chicago and the last cluster covers the south side of Chicago. Data derived from the clusters are then extrapolated to sites not visited but in close proximity to those that are, based on the amount of effort observed via the helicopter flights.

The season is divided into three week segments starting on April 1 and ending on September 30. It is further stratified by week day and weekend. Holidays are classified as weekends. A random number table is used in conjunction with a code table (all the possible combinations of 1 through 4 with each combination assigned a number) to determine the days creeled and what clusters are creeled on a given day; with the restriction that each cluster will be visited once during the week and once during the weekend. The random number table is also used to determine which weekday and or weekend day will not be creeled in a given week (in segments with seven weekend days (a holiday), we only creel six weekend days per segment. The angler types contacted directly are pedestrian (structure, shore, and harbor) and launched boat anglers (ramp). The time of the day each site is visited is not random. The first pedestrian site is always visited at 6:00, the second at 8:30 and the launched boat site at 11:00. Each site visit is always two hours long. Other time periods were sampled in 1985 through 1988 and the pattern of angler usage observed, especially in Chicago, indicated that these were the best times to sample. Factors such as traffic and use of the parks and launch ramps by other user groups decreased angler use in the afternoon and evening.

Creel clerk effort is divided 50-50 between the two day type strata. Per week, 4 creel clerk days are used on the week days and 4 creel clerk days are used on the weekend. Over the course of the survey 20.8% of the week days and 47.3% of the weekend days are creeled per site. By month each site is visited 7 to 9 days a month. The visits are not randomly stratified by the time of the day. Certain pedestrian sites are always visited between 6:00 and 8:00, other pedestrian sites are always visited between 8:30 and 10:30 and the launched boat angler sites are always visited between 11:00 and 13:00. Pedestrian catch and effort observed during interviews are expanded over the course of the day with the assumption that they are representative of the whole day. There is a correction factor for the time of the day but it has been set to 1 (the original designer of the survey had hoped to obtain enough data that a true correction factor could have been derived). A correction factor for launched boat catch and effort was derived through observation of boats returning to the ramp between 8:00 to sundown on 47 different days between 1985 - 1988. This corrects for the return rate of boats between 11:00 to 13:00 compared with the rest of the day. Other estimates used in our calculations include percent of effort observed through helicopter flights of the shoreline, which is used in extrapolating our data from the twelve sites that we visit to the rest of sites along the lake. Estimates of moored boat effort and catch were determined by comparing the rate of return between launched boats and moored boats between 11:00 and 13:00 and the rest of the fishing day. Ratios derived from these observations between 1987 - 1988 have since been used to extrapolate moored boat effort and catch from launched boats. Separate ratios were derived for three different harbors, with the estimates arrived at those harbors extrapolated to surrounding harbors not creeled. The number of moored boats per harbor is updated annually through the specific harbor authorities. Unfortunately, transient moored boats are not counted using this method but the number of such boats is believed to be small. I/O (dry stacked) boats are accounted for only at Waukegan Harbor, and moored and I/O boats in the Chicago and Calumet River systems are not accounted for; it is believed that the majority of these boats are non- fishing boats.

Table 2a. Summary of Pedestrian sites used in the Illinois Lake Michigan creel survey. Site abbreviations are defined in Table 3.

Year	Primary Pedestrian Sites	Secondary Pedestrian Sites
1985	Wauhar, Montro	SBluff, Waupow, GLNTC, Forest, Centrl, Tower, Wilmet, Dawes, Farwell, Hollywd, Foster, Belmont, Divers, Nave, Navy, Shdbur, 31st, 50th, 59th, Jacksn, Rainbw, Cal
1986	Waupow, Wauhar, Montro, Shdbur, Jacksn, Cal	SBluff, GLNTC, Forest, Centrl, Tower, Wilmet, Dawes, Farwell, Hollywd, Foster, Belmont, Divers, Nave, Navy, Monroe, Mcormk, 31st, 50th, 59th, Rainbw
1987	Waupow, Wauhar, Montro, Divers, Shdbur, Mcormk, Jacksn, Cal	SBluff, GLNTC, Forest, Centrl, Tower, Wilmet, Dawes, Farwell, Hollywd, Foster, Belmont, Nave, Navy, Monroe, 31st, 50th, 59th, Rainbw
1988	Waupow, Wauhar, Montro, Divers, Shdbur, Mcormk, Jacksn, Cal	SBluff, GLNTC, Forest, Centrl, Tower, Wilmet, Dawes, Farwell, Hollywd, Foster, Belmont, Nave, Navy, Monroe, 31st, 50th, 59th, Rainbw
1989	Waupow, Wauhar, Montro, Divers, Shdbur, Mcormk, Jacksn, Cal	NPoint, GLNTC, Forest, Centrl, Tower, Wilmet, Dawes, Farwell, Hollywd, Foster, Belmont, Nave, Navy, Monroe, 31st, 50th, 59th, Rainbw
1990 - 1995	Waupow, Wauhar, Montro, Divers, Shdbur, Mcormk, Jacksn, Cal	NPoint, GLNTC, Forest, Centrl, Tower, Wilmet, Dawes, Farwell, Hollywd, Foster, Belmont, Nave, Navy, Monroe, 31st, 50th, 59th, Rainbw

Table 2b. Summary of Boat sites used in the Illinois Lake Michigan creel survey. Site abbreviations are defined in Table 3.

Year	Primary Launched Boat Sites	Secondary Launched Boat Sites	Moored Boat Sites
1985	Wauhar, Divers	SBluff, GLNTC, Centrl, Tower, Dawes, Wilson, Shdbur, 59th, Jacksn, Rainbw, Cal, Forest	Wauhar, GLNTC, Wilmet, Chicago Park District Harbors
1986	Wauhar, Divers, Cal	SBluff, GLNTC, Centrl, Tower, Dawes, Wilson, Shdbur, 59th, Jacksn, Rainbw, Forest	Wauhar, GLNTC, Wilmet, Chicago Park District Harbors
1987	Wauhar, Divers, ShdburE, Cal	SBluff, GLNTC, Centrl, Tower, Dawes, Wilson, ShdburW, 59th, Jacksn, Rainbw, Forest	Wauhar, GLNTC, Wilmet, Chicago Park District Harbors
1988	Wauhar, Divers, ShdburE, Cal	SBluff, GLNTC, Centrl, Tower, Dawes, Wilson, ShdburW, 59th, Jacksn, Rainbw, Forest	Wauhar, GLNTC, Wilmet, Chicago Park District Harbors
1989	Wauhar, Divers, ShdburE, Cal	NPoint, GLNTC, Centrl, Tower, Dawes, Wilson, ShdburW, 59th, Jacksn, Rainbw, Forest	NPoint, Wauhar, GLNTC, Wilmet, Chicago Park District Harbors

1990	Wauhar, Divers, ShdburE, Cal	NPoint, GLNTC, Centrl, Tower, Dawes, Wilson, ShdburW, 59th, Jacksn, Rainbw, Forest	NPoint, Wauhar, GLNTC, Wilmet, Chicago Park District Harbors
1991	NPoint, Divers, ShdburE, Cal	Wauhar, GLNTC, Centrl, Tower, Dawes, Wilson, ShdburW, Jacksn, Rainbw, Forest	NPoint, Wauhar, GLNTC, Wilmet, Chicago Park District Harbors
1992	NPoint, Divers, ShdburE, Cal	Wauhar, GLNTC, Centrl, Tower, Dawes, Wilson, ShdburW, Jacksn, Rainbw, Forest	NPoint, Wauhar, GLNTC, Wilmet, Chicago Park District Harbors
1993	NPoint, Divers, ShdburW, Cal	Wauhar, GLNTC, Centrl, Tower, Dawes, Wilson, ShdburE, Jacksn, Forest	NPoint, Wauhar, GLNTC, Wilmet, Chicago Park District Harbors
1994 - 1995	NPoint, Divers, ShdburW, Cal	Wauhar, GLNTC, Centrl, Tower, Dawes, Wilson, ShdburE, Jacksn, Forest	NPoint, Wauhar, GLNTC, Wilmet, Chicago Park District Harbors

Table 3. Abbreviations and full names of sites used in the Illinois Lake Michigan creel survey.

Abbreviation	**Full Name**	**Site Location**
SBluff	Spring Bluff Forest Preserve	Winthrop Harbor
NPoint	North Point Marina	Winthrop Harbor
Waupow	Waukegan Power Plant	Waukegan
Wauhar	Waukegan Harbor	Waukegan
GLNTC	Great Lakes Naval Training Center	North Chicago
Forest	Forest Park	Lake Forest
Centrl	Central Park	Highland Park
Tower	Lloyd and Tower Parks	Winnetka
Wilmet	Wilmette Harbor	Wilmette
Dawes	Northwestern University and Dawes Park	Evanston
Farwell	Farwell Ave Pier	Chicago
Hollywd	Hollywood Ave Pier	Chicago
Foster	Foster Ave Pier	Chicago
Wilson	Wilson Ave Ramp	Chicago
Montro	Montrose Ave Harbor	Chicago
Belmont	Belmont Ave Harbor	Chicago
Divers	Diversey Ave Harbor	Chicago
Nave	North Ave Pier and Beach	Chicago
Navy	Navy Pier	Chicago
Monroe	Monroe St. Harbor	Chicago
Shdbur	Shedd and Burnham Ave Harbor, ramps at both the west and east sides of the harbor	Chicago
Mcormk	McCormick Place	Chicago
31st	31st St. Pier	Chicago
50th	50th St. Park	Chicago
59th	59th St. Harbor	Chicago
Jacksn	Jackson Park Harbor	Chicago
Rainbw	Rainbow Beach	Chicago

Cal	Calumet Park	Chicago

Angler contact methodology

Anglers are contacted directly by creel clerks either while they are fishing (pedestrian sites) or when they return to the launch ramp (launched boat angler sites). All anglers or boat trailers are counted at the beginning of an interview set and again at the end of that set. **All anglers** are interviewed at each site unless the numbers are too large to interview in two hours, then a subsample is interviewed.

Data collected

Data are collected on **effort**, **catch**, and **economics**. Fish are **identified, weighed (grams), measured (total length, in centimeters)** and checked for **clips, tags,** and **lamprey wounds** and **scars.**

The length (total length), weight, clips, lamprey eel wounds and scars are recorded during the regular interview period from interviewed anglers. These data are summarized and presented in the annual creel report. The data are presented as: average lengths by species compared to previous years; length distributions by species and for certain species by season; biomass (derived by average weight * number of fish harvested) of each species harvested and the market value of that catch; average weight of each species, by season and angler type; clipped fish by species, season and angler type. Currently the lamprey eel wound and scar data are not presented on an annual basis.

Effort, catch and CPUE

The data collected in the interviews on one date at one area are reduced to a set of variables describing daily fishing activity:

(1) **Catch per angler-hour** is determined for each species as the number of fish caught by all parties interviewed divided by the number of hours of fishing by individuals in those parties.

(2) **Expenditures** per angler-trip are determined in each of three categories (major, minor, and other). For "major" expenditures, total expenditures by all anglers interviewed are divided by the number of anglers interviewed. For "minor" and "other" expenditures, average expenditures per angler-trip are derived from past creel survey data but in 1994 "minor" and "other" expenditures are determined in the same manner as "major" expenditures.

(3) **Angler-hours** (i.e., total time spent fishing by all anglers) and (4) **angler-trips** (i.e., total number of anglers who fished) are determined differently for pedestrians and boaters. For pedestrians, angler-hours is the average number of anglers (at start and finish of interviews) multiplied by the number of hours in the day (from 0.5 hour before sunrise to 0.5 hour after sunset), and angler-trips is angler-hours divided by the average duration of a pedestrian fishing trip (4.31 hours for all interviews with conventional pedestrian anglers during the 1987 survey). The number of fishing boats launched for the day is estimated by multiplying the number of fishing boats landing during the two-hour interview period by the estimated average ratio of the number of all boats returning in a day to the number returning between 11:00 a.m. and 1:00 p.m. That ratio was estimated to be 3.13 by monitoring all boat traffic at one of three launch ramps on 47 days in 1985 through 1988. Angler-trips are then estimated as the total number of boats launched for the day multiplied by the average number of anglers per boat (2.77, based on data from 1987). Angler-hours are taken as angler-trips multiplied by the yearly average number of hours per angling trip by boaters (5.25, based on data from 1987).

(5) **Catch** is determined for each species as catch per angler-hour multiplied by angler-hours.

(6) **Expenditures** are determined for each category as expenditures per angler-trip multiplied by angler- trips.

Per site

Daily launched boat effort = **L * C**

Daily launched boat catch by species = **D_s * L * C**

Daily boat angler expenses = **E * L**

Daily pedestrian effort = **R * H**

Daily pedestrian catch by species = **D_s * P**

Daily pedestrian angler trips = **P / (avemhc / avemha)**

Daily pedestrian expenses = **E * (P / pedtrip)**

CPE expansion = **(ΣD_s) / sumday**
Where: Ds are summed by species with each segment.

Expansion per segment per site and angler type for effort

Total effort for pedestrians at creeled sites = **(avepedeff1 * Ndaysd1) + (avepedeff2 * Ndaysd2)**

Total catch for pedestrians at creeled sites = **(avepedcth1 * Ndaysd1) + (avepedcth2 * Ndaysd2)**

Total expenses for pedestrians at creeled sites = **(avepedexp1 * Ndaysd1) + (avepedexp2 * Ndaysd2)**

Total effort for launched boats at creeled sites = **(avelaueff1 * Ndaysd1) + (avelaueff2 * Ndaysd2)**

Total catch for launched boats at creeled sites = **(avelaucth1 * Ndaysd1) + (avelaucth2 * Ndaysd2)**

Total expenses for launched boats at creeled sites = **(avelauexp1 * Ndaysd1) + (avelauexp2 * Ndaysd2)**

Expansion of primary site effort and catch to other sites by segment

A table is set up each year with the percentage of observed effort at each site for the entire Illinois shoreline derived through helicopter flights. Each primary site has a percentage of the total effort as do the other sites. Sites not creeled are grouped near each primary site and the sum of their percentages are used in the following calculations. Launched boat effort is used here as an example; a similar equation is used for both angler types and also for catch and expenses.

(npeff * npx) + (dveff * dvx) + (bweff * bwx) + (cleff * clx)

Moored boat survey design

Moored boat effort, catch and expenses are estimated using ratios in conjunction with launched boat results. For example, the moored boat effort at Diversey Harbor in Chicago would be: **Diveff * Divr**. The ratios are the proportion of boat returns to moorings versus boats returning to the ramp and are estimated over the entire day. The ratios were derived from data collected from 1985 through 1988. New data are in the process of being collected in 1995.

For moored boats in harbors that we don't creel the following equation is used:

(Divmoor + Burnmoor) * Chimoor + (Npmoor * Northmoor)

Table 4. List of variables used in creel calculations

A = daily number of launched boat anglers returning to the ramp **(anghr * 2 * brat)**.
Anghr = number of boat anglers returning to the ramp per hour.
Avebtra = average number of anglers per boat, averaged from all creeled launched boat sites during a particular segment for the current year.
Avebtrc = average number of anglers per boat, a constant derived from the average number of anglers per boat from all creeled sites in 1987.
Avelaucth1 = average daily catch (per species) for all week days creeled.
Avelaucth2 = average daily catch (per species) for all weekend / holidays creeled.
Avelaueff1 = average daily effort for all week days creeled.
Avelaueff2 = average daily effort for all weekend / holidays creeled.
Avelauexp1 = average daily expenses (by category) for all week days creeled.
Avelauexp2 = average daily expenses (by category) for all weekend / holidays creeled.
Avemha = average trip length derived from actual average trip length (average for all pedestrian sites that segment based on how long the anglers thought they would fish).
Avemhc = average trip length derived as a constant from 1987 observations of complete pedestrian trips.
Avepedcth1 = average daily catch (per species) for all week days creeled.
Avepedcth2 = average daily catch (per species) for all weekend / holidays creeled.
Avepedeff1 = average daily effort for all week days creeled.
Avepedeff2 = average daily effort for all weekend / holidays creeled.
Avepedexp1 = average daily expenses (by category) for all week days creeled.
Avepedexp2 = average daily expenses (by category) for all weekend / holidays creeled.
B = average number of anglers per boat **(avbtrc / avebtra)**.
Brat= a correction factor, a ratio of boats returning between 11:00 to 13:00 versus the rest of the day. This factor was derived between 1986 -1988 based on actual observations.
Burnmoor = Burnham harbor total (effort, catch, or expenses).
Bweff = launched boat effort at Burnham Harbor west ramp for a segment.
Bwx = s um of % of other sites near Burnham Harbor west ramp / % of Burnham Harbor west ramp.
C = a verage daily trip length for launched boats **(hptc / hpta)**.
Chimoor = ratio derived from the number of moored boats in harbors in Chicago other than Diversey and Burnham compared to the sum of boats moored in Diversey and Burnham harbors.
Cleff = launched boat angler effort at Calumet Park for that segment.
Clx = sum of % of other sites near Calumet Park / % of Calumet Park.
Divmoor = Diversey harbor total (effort, catch or expenses).
Divr = a ratio derived by comparing the number of boats returning to the launch ramp to the number of boats returning to their moorings.
Ds = catch per unit effort with effort targeted for each species or species group targeted, T_s / M_s where $_s$ = species or species group.
Dveff = launched boat angler effort at Diversey Harbor for a given segment.
Dvx = sum of % of other sites near Diversey Harbor / % of Diversey Harbor.
E = average expenses per angler, **exsum / numangs**.
Exsum = sum of expenses for each category.
H = the length of the fishing day one half hour before sunrise to one half hour after sunset in units of a tenth of an hour
Hpta = the average duration of a launched boat angling trip, averaged from all creeled launched boat sites during that segment for the current year.
Hptc = the average duration of a launched boat angling trip as a constant derived from the average trip length observed in 1987.
L = Daily Launched boat trips **A*B**
Laucth = daily launched boat catch by species **(T / M) * L * C**.
Laueff = daily launched boat angler effort **(anghr * 2 * brat) * (avebtrc / avebtra) * (hptc / hpta)**.
M_s = total number of angler hours by anglers specifically fishing for either salmonids or yellow perch. Anglers fishing for anything that bites or other species (bass, carp, etc.) are not included.
Ndaysd1 = total number of week days that segment.
Ndaysd2 = total number of weekend / holidays that segment.
Northmoor = ratio derived from the number of moored boats in Lake County and Wilmette other than North Point compared to the number of moored boats at North Point.
Npeff = launched boat angler effort at North Point Marina for that segment.
Npmoor = North Point Marina total (effort, catch or expenses).
Npx = sum of % of other sites near North Point / % of North Point Marina.
Numangs = the number of anglers interviewed.
Pedcth = daily pedestrian catch, **cph * P**.
P = daily pedestrian effort, **R * H**.
Pedexp = daily pedestrian expenses, **expangs * (P / pedtrip)**
Pedtrip = average daily pedestrian angler trip length, **avemhc / avemha.**
R = sum of beginning and end counts of pedestrians divided by two.
Sumday = the number of days creeled in that segment where effort occurred for that particular species.
T_x = actual catch (by species) observed by anglers specifically fishing for either yellow perch or salmonids.

Variance calculations

No variance estimates are calculated.

Evaluation of methods and estimates

We acknowledge that there is bias in our survey since we use a number of estimated parameters and a number of assumptions such that angler effort and catch rates during our interview times are on average representative for the entire day. Currently, however, we do not evaluate bias, accuracy or precision.

Quality control

No regular, formal checks are made on clerks in the field. However, creel clerks are often visited or observed by members of the staff when the staff are engaged in other field activities. The clerks are initially trained by experienced members of the staff, and are usually paired in this manner for their first week of the survey. All of the field data collected by the clerks is checked within three weeks of collection (clerks have to turn in their data sheets at least every three weeks), at which time problems are identified and brought to the attention of the clerk. After the data are entered in the computer, the data are proofed and corrected.

Creel forms

A sample creel interview sheet and schedule is given in Appendix 2.

Recommended changes to creel survey

a) Collect enough data to arrive at a correction factor for pedestrian angler effort, catch and expenditures and periodically update through data collection.
b) Periodically update all of the constants used in the extrapolation process through more extensive data collections.

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CREEL SURVEY OF THE INDIANA WATERS OF LAKE MICHIGAN

Geographic area

The geographic setting of this survey includes the **Indiana shoreline of Lake Michigan** and **two major tributary streams**. Indiana oversees approximately 1% of Lake Michigan [224 square miles], 43 miles of shoreline. Most of the area is highly developed and industrialized, with the exception of the Dunes National Lakeshore and the Indiana Dunes State Park. Our creel survey incorporates four main lakefront areas: Washington Park Marina, Michigan City; Port of Indiana, Burns Harbor; Robert A. Pastrick Marina, East Chicago and the Hammond Marina. Four coal-fired power plants are also located along the shoreline, which include: Northern Indiana Public Service Company (NIPSCO) Michigan City Generating Station; NIPSCO Bailly Generating Station, Burns Harbor; NIPSCO Dean H. Mitchell Generating Station, Gary; Commonwealth Edison State Line Power Station, Hammond. The NIPSCO Michigan City and Gary discharge, along with the Commonwealth Edison State Line discharge provide fishing opportunities for pedestrian anglers. No public entry is allowed at the NIPSCO Bailly Generating Station, although limited access exists just west of the Indiana Dunes National Lakeshore-Boat in Beach. These discharges have been incorporated in the creel surveys of past years, but are not included in the current creel sampling design. Various industries along Indiana's shoreline of Lake Michigan also provide access to pedestrian anglers (e.g. Bethlehem Steel; Midwest Steel, boat-in beach between Burns Waterway and Port of Indiana, Portage; Hammond Water Filtration Plant, fishing allowed from rip-rap covered shore surrounding the plant), but are not encompassed into our current lake survey. Most of the Dunes National Lakeshore beaches are accessible to pedestrian anglers, with fishing allowed outside bathing beach areas [Boat in Beach (Burns Harbor); Central Avenue Beach (Beverly Shores); Kemil Road Beach (Beverly Shores); Lakeview Beach (Beverly Shores); Miller Beach in Gary, public access to the breakwall at USX via the beach; Mt. Baldy Beach (Michigan City)]; however, fishing is limited to smelt fishing in the spring.

The two main Lake Michigan tributaries, Trail Creek and the East Branch of the Little Calumet River (Salt Creek) flow through land with a variety of uses. These uses range from roadways, industrial (waste treatment plant; steelmill effluent), to agricultural. The geographical area of this survey is illustrated in Figures A, B, and C in Appendix 3.

Creel sampling dates

Since 1969, the Indiana Department of Natural Resources have been releasing trout and salmon along the Indiana shoreline of Lake Michigan to alleviate an overabundance of alewives, along with providing the public with increased sport angling opportunities. Since 1973, Indiana has conducted lake and stream creel surveys to assess stocking programs. Catch, effort and biological data are used to document trends in the Lake Michigan fishery. The following table is a summary of the creel sampling dates for the last 20 years of Indiana's lake/stream creel program:

YEAR	LAKE CREEL	STREAM CREEL
1994	April 1 - October 31	January 1 - March 31 July 1 - December 31
1993	April 1 - October 31	January 1 - March 31 July 1 - December 31
1992	April 1 - October 31	January 1 - March 31 July 1 - December 31

1991	March 19 to October 31	January 1 - March 31 July 1 - December 31
1990	March 22 to October 31	January 1 - March 31 July 1 - December 31
1989	April 1 to November 12	January 1 - March 31 July 1 - December 31
1988	April 2 to September 26	January 1 - March 31 July 1 - December 31
1987	April 1 to October 31	August 1 - November 22
1986	April 1 to October 31	August 14 - November 10
1985	May 1 to October 27	July 29 - November 17
1984	May 1 to November 10	July 28 - November 25
1983	March 19 - November 19 Discharges: Sept. 10 - Oct. 15	August 1 - November 24
1982	March 22 - November 7 Discharges: Sept. 10-29	July 24 - November 21
1981	March 1 - November 23 Discharges: February - May Sept. - Oct.	August 6 - November 15
1980	April 1 - November 23 Discharges: January - April	September - November
June 1978 - May 1979	June - November; March - May; Discharges: July - December (Sept. omitted) January - May	September 18 - November 19, 1978
1977	March 28 - June 30 September 1 - November 13	October 6 - November 20
1976	March 24 - June 30 September 20 - November 14	October 3 - November 14
1975	March 24 - June 30 September 6 - November 19	October 1 - November 19
1974	August to November (lack of funding precluded a survey in April - June)	September 23 - November 30

Fishery types

The present survey samples:

BOAT

Sport fishing from boats (including charter boats) is monitored at four sites:

1. Michigan City at Washington Park and Sprague Marina (MC)
2. Burns Harbor at numerous private ramps and slips on Burns Waterway (BH)
3. East Chicago at Pastrick marina (EC)
4. Hammond at Hammond marina (HA)

SHORE

Creel Clerks monitor the shore fishery while surveying the boat fishery:

1. Washington Park pier (MC)
2. Port of Indiana public access site (Burns Harbor)
3. East Chicago pier (EC)
4. Hammond pier (HA)

Limited access to warmwater discharges is also provided by industrial plants for shore angling opportunities. These include: Commonwealth Edison State-Line power station in Hammond, the Amoco Oil Company in Whiting, and the Northern Indiana Public Service Company generating stations in Michigan City and Gary. All of these previously listed discharges allow fishing with access restricted during adverse weather conditions due to dangers associated with high winds and/or icy conditions. Although these industries allow access to pedestrian anglers, our present creel survey design does not include sampling at any of these sites.

STREAM

Creel surveys are conducted at Trail Creek in LaPorte County, the East Branch of the Little Calumet River and Salt Creek in Porter County. The stream creel design incorporates the most effective sampling of the stocked tributaries to Lake Michigan. The only exception is the St. Joseph River Interstate Anadromous Fish Project. This project was initiated by the Michigan and Indiana Departments of Natural Resources to provide passage of migratory fish into urban areas, thus providing angling opportunities otherwise unavailable to residents of the communities along the river from the Lake Michigan river mouth through Mishawaka, Indiana. Although a creel program does exist for the St. Joseph River project, it directly falls into Fisheries Management District 2; therefore, the Lake Michigan Investigations office is not directly involved in implementation of the St. Joseph River creel program.

The following table summarizes the survey area covered for the last 20 years of Indiana lake/stream creel program:

YEAR	BOAT FISHERY SITE	SHORE FISHERY SITES	STREAM FISHERY SITES
1993, 1992 and 1991	MC BH EC HA	MC BH EC HA	TC LC SC

1990	MC (Wash. Park & Sprague) EC (Pastrick) BH (Lefty's Marina)	EC pier MC pier	TC LC SC
1989	MC (Wash. Park & Sprague) EC (Pastrick) BH (Lefty's)	EC pier MC pier	TC LC SC
1988	MC (MC Yacht Basin) EC (Jeorse Park) BH (Lefty's)	EC (Jeorse Park) MC	TC LC SC
1987 1986	MC (MC Yacht Basin) EC (Jeorse Park) BH (Lefty's)	EC (Jeorse Park) MC [NIPSCO Generating Stations: MC, Gary (Jan. - March & Nov. - Dec.) Commonwealth State-Line Generating Station (Jan. - March & Nov. - Dec.)]	TC LC SC
1985	MC (MC Yacht Basin) EC (Jeorse Park) BH (Lefty's)	EC (Jeorse Park) MC [NIPSCO Generating Stations: MC, Gary (Jan. - April & December) Commonwealth State-Line Generating Station (Jan. - April & December)]	TC LC SC

1984	MC (MC Yacht Basin) EC (Jeorse Park) BH (Lefty's)	EC (Jeorse Park) MC [NIPSCO Generating Stations: MC, Gary (Nov. 5 - Dec.) Commonwealth State-Line Generating Station (Nov. 5 - Dec.)	TC LC SC
1983 1982	MC (MC Yacht Basin) EC (Jeorse Park) BH (Lefty's)	EC (Jeorse Park) MC NIPSCO Generating Station: Gary, IN 1983: Sept. 10 - Oct. 15 1982: Sept. 10 - 29	TC LC SC
1981 1980 1979 1978	MC (MC Yacht Basin) EC (Jeorse Park) BH (Lefty's)	EC (Jeorse Park) MC NIPSCO Generating Stations: MC, Gary 1981: Feb.- May Sept. - Oct. 1980: Jan. - April 1979/1978: July - Aug. Oct. - Dec. Jan. - May	TC LC SC
1977 1976 1975	MC (MC Yacht Basin) EC (Jeorse Park) BH (Lefty's)	EC (Jeorse Park) MC	TC LC SC
1974	MC (MC Yacht Basin) EC (Jeorse Park) BH (Lefty's)	MC	TC LC SC

Creel survey sampling design

The sampling design used in this survey is a design with randomly selected clusters (sites within areas, days with month/daytype) and simple random subsamples of anglers within these clusters. It is not a true stratified random sampling design due to the processes used for sample selection. Data for each fishery are stratified by site, month, and day type (weekends/holidays and weekdays) prior to summarization and expansion. The boat and shore data are further stratified by species sought (four categories: salmonids, yellow perch, bass, and all other species).

Lake Michigan boat and shore fishery

Sport fishing from boats is monitored at four sites: Michigan City at Washington Park and Sprague marinas; Burns Harbor at numerous private ramps and slips on Burns Waterway; East Chicago at Pastrick Park marina; and Hammond at Hammond marina. While surveying the boat fishery, the creel clerk also monitors the shore fishery at the Michigan City, East Chicago and Hammond piers and at the Port of Indiana public access site in Burns Harbor. Lake creel is conducted from the months of April through October.

The sampled fishing season is broken up into weeks, each of which is subdivided into weekends and weekdays. Holidays are classified as weekend days. Sampling effort is allocated so that each of the sites is sampled each weekend. Because one creel clerk samples a single site during a day, this requires that two clerks sample each weekend day. Which sites are sampled each weekend day are determined through random selection (without replacement). Each of the four sites is sampled once on the weekdays during the week. The order of sampling is selected via random selection without replacement.

The selection of sampling days follows a stratified design with the combination of site and weekend or set of weekdays within an individual week forming the strata. One primary sampling unit (day) is selected within each stratum. Each potential day selected within a stratum has equal probability of being selected. This design deviates from a stratified random design in that choices of sampling units (days) are not independent across strata. Angler interviews and fishing effort within the day are subsampled as described above, containing some systematic elements.

The creel clerk remains at one of the four sites for an 8 hour 22 minute shift [due to a work hours policy change, personnel can not work over 37.5 hours/week; therefore, a creel clerk works a total of 4 days/week (2 weekdays and 2 weekend days)]. Effort is measured for both boat and shore/pier fisheries during each hour. Effort is measured once each hour over the survey day, with the start time (at 20 minute intervals) for the first hour selected randomly (three count periods exist: 00:00, 00:20, and 00:40). Three work shifts exist: 8:00 a.m. to 4:20 p.m. or
8:20 a.m. to 4:40 p.m. or
8:40 a.m. to 5:00 p.m.

Launched boat/slip anglers are interviewed and their days catch examined when the boats return to the launched boat angler site (completed trips). Pedestrian anglers are contacted directly at each site. Data from complete and incomplete fishing trips are collected. All anglers are interviewed unless there exists too large a number to interview in the 40 minute allotted interview time period between boat and shore/pier counts. If this does occur, a subsample is interviewed.

Data are classified by site, month, day type (weekend/holiday and weekdays), fishing mode and (for interviews) by target (yellow perch, salmonids, bass or other) prior to summarization and expansion. Data for each such combination are treated as one large sample from that site/month/day type, fishing mode and target.

Stream fishery

Sport fishing surveys are conducted at Trail Creek in LaPorte County, the East Branch of the Little Calumet River and Salt Creek in Porter County. Creel survey schedules, are created in a similar fashion as described in the lake fishery section above. The sampled angler season is broken into weeks, each of which is subdivided into weekends and weekdays (holidays are classified as weekend days). Sampling effort is allocated so that each of the sites is sampled a minimum of 2 weekends(holidays)/month (January, February, November and December). The only difference with sampling effort occurs during the months of March and July through October. Trail Creek is sampled twice as much as Little Calumet and Salt Creek due to the greater fishing effort upon Trail Creek from the skamania and salmonid runs. Trail Creek is sampled a total of 4 weekends(holidays)/month. Which sites are sampled each weekend day are determined through random selection (without replacement). Each of the three creeks is sampled a minimum of 4 weekdays/month (exception occurs during the months when Trail Creek is sampled with double effort, Little Calumet and Salt Creek are only sampled 2 weekdays/month).

The selection of sampling days follows a stratified design with the combination of site and weekend or set of weekdays within an individual week forming the strata. One primary sampling unit (day) is selected within each stratum. Each potential day selected within a stratum has equal probability of being selected. Again, this design deviates from the stratified design in that the choices of sampling days are not independent across strata. The days the individual sites are selected are not independent because the sampler can only sample one location at a time. Angler interviews and fishing effort within the day are subsampled as described above, containing some systematic elements.

Effort (driving the entire stream stopping at approx. thirteen access sites to count angler vehicles) is measured three times over the survey day, with the start time for the three counts selected randomly. Pedestrian anglers are contacted directly at each site upon a stream. Data from completed and incomplete angling trips are collected.

There exists only one set shift. For the months of **January, February, November** and **December,** a single 7.5 hour shift is used to represent daylight hours (8:00 a.m. to 3:30 p.m.). A 9hour 20minute shift is used in **March,** and **July through October** (7:30 a.m. to 4:50 p.m. or 8:10 a.m. to 5:30 p.m.).

Data are classified by site, month, day type (weekend/holiday and weekdays), and (for interviews) by target (species) prior to summarization and expansion.

Data collected

Data are collected on effort, targeted effort, harvest and catch. Fish are identified, measured (total length, in inches to the nearest 0.1) and checked for fin clips. Presently scale samples are obtained for age analysis.

Effort, catch and CPUE

Boat

Angling effort and harvest from boats for each data stratum (month, site, weekend/weekday), are summarized, then expanded using:

(1) Expanded angler hours = 3 $(a_B)(b_B)(c_B)(d)$

where (a_B) = mean twenty-minute (1/3 hour) boat count*

(b_B) = mean complete trip length for boats

(c_B) = the mean number of anglers per boat

(d) = possible fishing hours **

* Further stratified by the percent of boats fishing for salmonids, perch, bass, and others, determined from interviews (directed effort).

** Possible fishing hours was defined as 14 hours/day April through September, and 12 hours/day in October.

(2) Expanded harvest = (expanded angler hours)(e/f)

where (e) = harvest recorded in survey (actual harvest)

(f) = angler hours recorded in survey (actual effort)

Shore

Angling effort from shore for each data stratum is summarized (site, month, weekend/weekday), then expanded using the equation:

(3) Expanded angler hours = $(a_{SH})(d)$

where (a_{SH}) = mean hourly shore angler count*

(d) = possible fishing hours

* Further stratified by the percent of shore anglers fishing for salmonids, perch, bass and others, determined from interviews (directed effort).

Fish harvested by shore fishermen is summarized, then expanded using equation (2).

Stream

Angling effort at streams for each data stratum is summarized, then expanded using the equation:

(4) Expanded angler hours = $(a_{ST})(c_{ST})(d) + (w)(d/e)$

where (a_{ST}) = mean vehicle count on streams

(c_{ST}) = mean number of anglers/vehicle on streams

(d) = possible fishing hours

(w) = hours from interviews for anglers without vehicles at stream count sites

(e) = survey hours

Stream harvest is summarized, then expanded using equation (2).

Variance calculations

No variance estimates are calculated.

Evaluations of methods and estimates

Bias, accuracy and precision calculations are not computed.

Quality Control

Formal checks are made upon the creel clerks in the field. Frequency of these checks varies, but usually occurs at least once every two weeks. The goal is a formal check at least once/week. Periodically, a member of the staff is sent out to informally check on the clerks; however, creel clerks are often observed by members of the staff when the staff are engaged in field activities.

The analysts are initially trained by the fisheries research technician, and are paired with the technician for the first couple days of the survey. Clerks are required to turn in their data sheets at the end of the day when returning to the Lake Michigan Investigations office. All of the field data collected by the clerks is checked within one to two days of their collection. Any problems with the data are identified and immediately brought to the attention of the clerk. Data are entered into the dbase monthly. The data are verified and corrected in the dbase before processing and report writing.

Creel forms

Samples of data sheets for the shore, boat, and stream fishery are in Appendix 3.

Recommended changes to creel survey

Throughout the past 20 years, Indiana's creel survey sampling design has continually changed to best reflect coverage upon Indiana's portion of Lake Michigan for fishery management decisions. Currently, our creel sampling design is being proposed for reevaluation prior to the 1996 sampling season. The only difficulty with a task of this magnitude is the feasibility (primarily restriction of funds/policies) of these proposed changes. Only a few recommended changes will be mentioned due to time constraints plus the fact that the reevaluation issues are still being discussed/proposed. The following is a short list of some proposals:

> Additions/Deletions of various sites (i.e. warm-water discharges, various industries) within our survey sampling area [possibly improve fishery (harvest/effort) estimates]
>
> Dropping Charter interviews (Indiana Charter operators currently are required by law to submit monthly catch reports)
>
> Reduction of Boat/pier effort (counts) within the sampling day
>
> Incorporation of a split-shift to cover the entire fishing day/site

Creel survey contact personnel

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CREEL SURVEY OF THE MICHIGAN WATERS OF LAKE MICHIGAN

Geographic area

The geographic area covered by the creel survey includes over 500 miles of shoreline from New Buffalo to Harbor Springs in Michigan's Lower Peninsula and Menominee to Big Bay de Noc in Michigan's Upper Peninsula (Figure 1). In general, most of the angler effort from New Buffalo to Harbor Springs has historically been directed at salmonines. However, yellow perch are important at such ports as St. Joseph, South Haven, Grand Haven, Muskegon and Ludington. Anglers in the Green Bay area, which in Michigan includes the area from Menominee to Little and Big Bays de Noc, direct most of their fishing effort toward yellow perch and walleye. Brown trout and splake also play an important role in the Green Bay fishery. Based on angler effort, the most actively fished ports in the Michigan waters of Lake Michigan include, St. Joseph, South Haven, Grand Haven, Ludington, Manistee, Frankfort and Little Bay de Noc.

Michigan's Great Lakes sport fishery usually begins during the middle of March at the southern most ports of New Buffalo and St. Joseph. That fishery is primarily composed of coho salmon and brown trout. During April to the middle of May fishing for the other species of salmonines and yellow perch begins to pick up in the New Buffalo to Muskegon area. After the middle of May sport fishing effort at the remaining Lake Michigan ports intensifies for salmonines as well as yellow perch and walleye.

At the present time 21 Lake Michigan ports/areas are sampled. The following ports are not sampled: Saugatuck, Port Sheldon, White Lake, Pentwater, Platte Bay, Leland and Manistique.

Creel sampling dates

Open water season:

Year	Start-end dates	Ports sampled
1985	April 1-November 15	27
1986	April 1-November 15	25
1987	March 15-October 31	28
1988	March 15-November 15	26
1989	March 15-November 15	19
1990	March 15-November 15	13
1991	March 15-November 15	15
1992	March 15-November 15	18
1993	April 1-October 31	21
1994	March 15-October 31	21

The ice fishery on Little Bay de Noc has been covered each year (1985-94) during January 1 through March 31. This fishery is primarily targeted at yellow perch and walleye. Approximately 90% of all ice fishing effort in the Michigan waters of Lake Michigan occur on Little Bay de Noc. Ice fishing also occurs on Green Bay (Menominee) Big Bay de Noc and on Grand Traverse Bays. The Grand Traverse Bay ice fishery does not occur every year because safe ice only forms during very cold winters. During the past ten years safe ice conditions only existed on the Bays in 3 or 4 years. During some of those years the ice was safe for fishing for only a 1-2 week period.

A limited number of tributary streams were surveyed during 1985-86. During 1985, large river fisheries such as the St. Joseph, Muskegon and Manistee were surveyed from April 1 to November 15. Also in 1985, sections of small river fisheries such as the Kalamazoo, Grand, Pentwater, Betsie, Platte, Bear, and Boyne rivers were surveyed during the spring (April-May) and fall (September-November). In 1986, streams were surveyed only during the spring and fall. The creel survey has never covered all the important anadromous stream fisheries during any given year.

Fishery types

Boat, shore, pier, open ice and shanty ice modes are counted and interviewed. During 1985-89 charter boats, moored boats and launched boats were combined as the "boat" mode of fishing. Beginning August 1, 1989, charter boats came under the Charter Boat Reporting Act and as a result charter boats were separated from the creel survey program and were not counted or interviewed. Therefore, after 1989 Michigan's boat mode of fishing consisted of moored and launched boats as the "boat" mode.

The Charter Boat Act requires all charter fishing operators to report their catch (harvest) and fishing effort to MDNR monthly throughout the fishing season (April through October). If charter operators do not fish during a particular month they are required to indicate such ("no fishing") on their monthly reporting form (see appendix for Michigan Charter Boat Daily Catch Report form).

Creel survey sampling design

The creel survey used in Michigan is based on a stratified design using structured random sampling within strata. Sampling strata used by Michigan are port fished, by weekday-weekend (holiday), and by mode of fishing.

Work (sampling) schedules are specifically tailored for the port or area being sampled. Both weekend days and three randomly selected weekdays are sampled each week. Weekdays sampled are selected by randomly choosing two weekdays (in series) for pass days out of each week. The remaining three weekdays are then work days. The entire angling day from dawn to 1-hour past dusk is covered. This is accomplished by breaking each day into two 8-hour work shifts, then randomly selecting the shift to be worked.

When an individual is responsible for sampling more than one port or area, the ports or areas are also randomly selected for each day. In addition, when a creel clerk is responsible for sampling more than one port, the monthly sample schedules are adjusted, if needed, so that there is some balance in the number of days sampled at each port. For example, since Michigan is attempting to make estimates for each month at two ports that a clerk may be responsible for we do not want the randomly generated schedule to be skewed so that for 20 working days of a month, 16 might occur at Port A while only 4 would occur at Port B.

All counts of pier, shore, ice shanties and open ice fisherman are instantaneous. Both instantaneous and interval boat counts are made. Generally, two counts are made each day at the selected port. The count times for the early or late shift are selected at random without replacement to insure that counts are made a various hours during the day during any given month.

In general, interval boat counts are made at sample areas where all boats must enter Lake Michigan through a defined channel (between pier heads). In this case, boats going out into the lake are counted twice each day at randomly chosen times for a 30 minute interval for each count time. Instantaneous counts of boats are made where the sample shoreline can be traversed by a creel clerk and all boats can be viewed and counted.

Harvest (kept, but not released fish) and effort estimates are generated for each combination of port, day-type, fishing mode, and month. These estimation strata differ to some extent from the design strata, and reflect pooling and post-stratification. The need to create estimates for these port, day-type, mode and month combinations has influenced the way we have "structured" random sampling and adjusted sampling schedules after randomization.

Creel clerks are also given a target number of biological (length, weight, etc.) samples to collect per month for each important species. The target sample numbers are based on the mean harvest of that species at each port during the previous three years. We are attempting to collect the largest number of bio-samples of a species during the month(s) when the peak harvest for that species usually occurs. In general, the numbers of samples required for the season are approximately 3-4% of the mean 3 year harvest for each important species. Clerks are instructed to collect biological samples throughout the entire month. Fish may be sampled during the interview process or, if the situation warrants, creel clerks are free to obtain biological data at fish cleaning stations or at charter boat docks.

Angler contact methodology

Angler parties are interviewed at the completion of their fishing trip(s). No incomplete trip interviews are used. Creel clerks may rove at all fishing sites (piers, launch ramps and marinas) at the selected port during the work day.

Data collected

Regular interview data are collected on each angler party's fishing effort (hours), catch (harvest), species targeted, fishing methods and demographics (sex and age of anglers as well as county or State of residence). Count data include the numbers of pier, shore and open ice anglers, as well as the numbers of boats (or interval count) or ice shanties. Estimates of the numbers of anglers per boat, or per ice shanty are collected from the angler party interview. Examples of the current data forms for angler party interviews and counts can be found in the appendix.

Creel clerks also collect biological data from the catch such as total length to the nearest tenth of an inch, round weight in pounds and a scale sample is obtained for age analysis. Also, fin clips, tags and lamprey wounds and scars are recorded. Heads and snouts are collect from all adipose fin clipped salmonines. During the period 1985-94 biological data were collected from all five species of salmonines and walleye. During 1985-92 biological data were also collected from yellow perch at all ports. In 1992-94 yellow perch biological data were collected only from the ports on Green Bay.

Effort, catch, CPUE and variance calculations

We describe how angler effort, harvest, harvest per unit effort, and associated variances are estimated from count and interview data collected by Michigan's Great Lakes creel survey. The software used to make these estimates is derived from a program used for creel survey data from inland waters. As such, the software handles more general situations than are encountered in the Great Lakes surveys. For example the software has provisions to deal with mixtures of single and multiple counts of anglers each day, and for analyzing interviews from incomplete angler trips, both of which almost never occur for the Great Lakes survey. Harvest and effort estimates are calculated for each combination of month, day type (weekday or weekend/holidays), port, and mode of fishing (boat which excludes charter, shore, pier, open ice, and shanty ice). We refer to each combination of month x day type x port x mode as a stratum. We emphasize, however, that these combinations reflect decisions on how to analyze and post-stratify data, not just strata built into the sampling design. Estimates of harvest and effort are then combined across strata to obtain estimates of harvest, effort and harvest per unit effort that apply to various combinations of day types, modes, months and ports. To simplify notation we have dropped the subscripts indicating strata, and where estimates apply to individual species of fish we have also dropped species subscripts. Thus, the equations describe calculations performed within each stratum and for individual species.

The following table lists symbols used in Michigan's equations and where they are defined:

Symbol	Description	Units	Equation Number (Defined In or Near)
$\hat{H}$	Estimated harvest	Fish	1
$\bar{r}$	Average Harvest Rate	Fish · hours^{-1}	1
$\hat{E}_{hrs}$	Estimated fishing Effort (Angler Hours)	Hours	1
n_{FI}	Number of fishing interviews	Interviews	3
r_i	Harvest rate for interview I	Fish · hours^{-1}	3
f_i	Number of fish harvested on interview I	Fish	3
a_i	Number of anglers for interview I	Anglers	3
e_i	Trip length (effort) for interview I	Hours	3
$\hat{P}_F$	Estimated proportion fishing	Unitless	5
$\hat{N}_{hrs}$	Estimated number of countable hours	Hours	5
$\bar{a}$	Average number of anglers	Anglers	5
F	Number of fishable hours	Hours	7
$\bar{\bar{c}}$	Grand mean count of anglers or parties	Instantaneous: anglers or parties Interval: parties^{-1}	7
n_I	Number of interviews	Interviews	9
n_{FP}	Number of interviewed people fishing	People	9

n_P	Number of interviewed people	People	9
n_T	Either n_I or n_P	Interviews or People	9
$\bar{e}_{CFI}$	Average trip length (effort) for completed fishing interviews	Hours	14
n_{CFI}	Number of interviews for completed fishing trips	Interviews	16
n_c	Number of counts in strata	Counts	18
n_{c_i}	Number of counts on day I	Counts	19
c_{ij}	Count j on day I	Parties or people	19
$\bar{c}_i$	Mean count on day I	Parties or people	20
$\hat{E}_{trips}$	Estimated fishing effort (trips)	Trips	23
$\bar{e}_{CFP}$	Average trip length for people with completed fishing interviews	Hours	23
n_{CFP}	Number of people fishing with completed interviews	People	25
$\hat{E}_{days}$	Estimated fishing effort days	Days	27
$\overline{t/a}_{FI}$	Mean numbers of trips (effort) per angler	Trips · anglers^{-1}	27
t_i	Number of trips for interview I	Hours	29
$\hat{H}_{CS}$	Estimated harvest for combined strata	Fish	31
$\hat{E}_{CS}$	Estimated effort for combined strata	Hours, trips, or days	31

$\hat{HPUE}_{CS}$	Estimated harvest per unit effort (combined strata)	Fish · $hours^{-1}$, Fish · $trips^{-1}$, or Fish · $days^{-1}$	31

Harvest Estimates for a Stratum

Harvest estimates (by species) ($\hat{H}$) are calculated as the product of an estimate of the harvest rate ($\bar{r}$) in harvest per hour (by species) and estimated total effort ($\hat{E}_{hrs}$) in angling hours:

$$\hat{H} = \bar{r} \times \hat{E}_{hrs} \tag{1}$$

With estimated variance:

$$\hat{Var}(\hat{H}) = \bar{r}^2 \hat{Var}(\hat{E}_{hrs}) + \hat{Var}(\bar{r})\ \hat{E}_{hrs}^{\ 2} \tag{2}$$

based on an approximate equation for the variance of a product of two independent random variables. We use this approximation repeatedly to obtain estimates of variances.

The estimated harvest rate, $\bar{r}$ is based on interview data, and is used as an intermediate value in the estimation of harvest. Reported harvest per unit effort is calculated in a separate step by dividing harvest estimates by effort estimates for the defined subset they apply to (e.g., time period, area, mode) as is described later. $\bar{r}$ is calculated as the mean harvest per hour over fishing interviews:

$$\bar{r} = \frac{\sum_{i=1}^{n_{FI}} r_i}{n_{FI}} \tag{3}$$

where $r_i = f_i/(a_i \times e_i)$ which is the harvest per angling hour by the ith party of a_i anglers that harvested f_i fish in a trip lasting e_i hours, and n_{FI} is the number of fishing interviews, which includes both complete and incomplete trips.

Variance for $\bar{r}$ is estimated as:

$$\hat{Var}(\bar{r}) = \frac{n_{FI} \sum_{i=1}^{n_{FI}} (r_i^2) - [\sum_{i=1}^{n_{FI}} r_i]^2}{n_{FI}^2 \, (n_{FI}-1)} \tag{4}$$

Estimates of $\hat{E}_{hrs}$ and $\hat{Var}(\hat{E}_{hrs})$ are from equations described in the next section.

Effort Estimates for a Stratum

Angling hours

Effort in angling hours ($\hat{E}_{hrs}$) is estimated differently depending upon whether instantaneous or interval counts of fishing activity are made, and whether angler parties or individual anglers are counted. Interval counts are made only for boat mode in some locations. Individual anglers are counted only for shore, pier/dock or open ice modes.

For cases where counts are of angler parties that may be composed of more than one individual (this occurs for shanty ice and for boat modes) and counts may be either interval (boat mode for some ports) or instantaneous, effort is estimated as:

$$\hat{E}_{hrs} = \hat{P}_F \times \hat{N}_{hrs} \times \bar{a} \tag{5}$$

where $\hat{P}_F$ is an estimate of the proportion of parties that fished, $\hat{N}_{hrs}$ is an estimate of the total number of hours spent in activities by parties that would be counted (even though some parties that are countable are not actually fishing) and $\bar{a}$ is the mean number of participants per fishing party. Variance is calculated as:

$$\hat{Var}(\hat{E}_{hrs}) = \hat{P}_F^2 \, [\hat{N}_{hrs}^2 \, \hat{Var}(\bar{a}) + \bar{a}^2 \, \hat{Var}(\hat{N}_{hrs})] + \hat{E}_{hrs}^2 \, \hat{Var}(\hat{P}_F) \tag{6}$$

For cases where single anglers are counted (shore, pier/dock, or open ice modes), which always represents instantaneous counts, effort is calculated as:

$$\hat{E}_{hrs} = F \times \hat{P}_F \times \bar{\bar{c}} \tag{7}$$

with estimated variance:

$$\hat{Var}(\hat{E}_{hrs}) = F^2\hat{P}_F^2 Var(\bar{\bar{c}}) + \hat{E}_{hrs}^2 \hat{Var}(\hat{P}_F) \qquad (8)$$

where F is an assumed known number of hours available within the stratum for fishing and $\bar{\bar{c}}$ is the grand mean number of parties tallied per count.

[While preparing this document it was noticed that equations 6 & 8 in existing written descriptions incorrectly apply the approximate variance equation for a product (the $\hat{E}_{hrs}$ in the last term on the right hand side of the equations should be $\hat{N}_{hrs} \times \bar{a}$ (equation 6) or $\hat{F} \times \hat{P}_F$ (equation 8)). The software may do the calculations correctly, but this needs to be checked.]

Intermediate calculations for angling hours

In equations 6-8, $\hat{P}_F$ is estimated simply as the number of interviews with some fishing reported (n_{FI}) divided by the number of interviews (n_I) (for use in equation 6) or as the number of people who did some fishing (n_{FP}) of the total number of people interviewed (n_P) (for use in equation 8). Its variance is estimated as:

$$\hat{Var}(\hat{P}_F) = \frac{\hat{P}_F \times (1 - \hat{P}_F)}{n_T} \qquad (9)$$

where T is either I or P for estimates based on numbers of interviews or people respectively.

$\bar{a}$ is estimated as:

$$\bar{a} = \frac{\sum_{i=1}^{n_{FI}} a_i}{n_{FI}} \qquad (10)$$

with estimated variance:

$$\hat{Var}(\bar{a}) = \frac{n_{FI}\sum_{i=1}^{n_{FI}} a_i^2 - [\sum_{i=1}^{n_{FI}} a_i]^2}{n_{FI}^2(n_{FI}-1)} \qquad (11)$$

Estimation of $\hat{N}_{hrs}$ depends on whether counts are interval or instantaneous. For instantaneous counts:

$$\hat{N}_{hrs} = F \times \bar{\bar{c}} \qquad (12)$$

with estimated variance:

$$\hat{Var}(\hat{N}_{hrs}) = F^2 \ \hat{Var}(\bar{\bar{c}}) \qquad (13)$$

For interval counts (expressed as counts per hour):

$$\hat{N}_{hrs} = F \times \bar{\bar{c}} \times \bar{e}_{CFI} \qquad (14)$$

With estimated variance:

$$\hat{Var}(\hat{N}_{hrs}) = F^2[\bar{\bar{c}}^2 \hat{Var}(\bar{e}_{CFI}) + \bar{e}_{CFI}{}^2 \hat{Var}(\bar{\bar{c}})] \qquad (15)$$

Here $\bar{e}_{CFI}$ represents the average trip length for parties interviewed at the completion of their trips:

$$\bar{e}_{CFI} = \frac{\sum_{i=1}^{n_{CFI}} e_i}{n_{CFI}} \qquad (16)$$

and n_{CFI} is the number of fishing interviews with complete trips. Estimated variance for $\bar{e}_{CFI}$ is given by:

Provided counts are expressed per hour for interval counts, calculation of the grand mean for counts and its variance follows the same procedure for both interval and instantaneous counts:

$$\hat{Var}(\bar{e}_{CFI}) = \frac{n_{CFI}\sum_{i=1}^{n_{CFI}} e_i^2 - [\sum_{i=1}^{n_{CFI}} e_i]^2}{n_{CFI}^2(n_{CFI} - 1)} \tag{17}$$

$$\bar{\bar{c}} = \frac{\sum_{i=1}^{n_C} \bar{c}_i}{n_C} \tag{18}$$

where n_C is the number of days for which counts are available, and the average count on day I is:

$$\bar{c}_i = \frac{\sum_{j=1}^{n_{C_i}} c_{i,j}}{n_{C_i}} \tag{19}$$

for n_{C_i} is counts on day I with $c_{i,j}$ being the value of the jth count on the ith day.

$\hat{Var}(\ \bar{\bar{c}}\ )$ is estimated in different ways depending upon whether multiple counts are made or not. During the production of this document we concluded that the way within and between day variances are treated needs review. Currently, if there are multiple counts each day then:

$$\hat{Var}(\bar{\bar{c}}) = \frac{\sum_{i=1}^{n_C} \hat{Var}(\bar{c}_i)}{n_C^2} \tag{20}$$

In the case without multiple counts:

$$\hat{Var}(\ \bar{\bar{c}}\ ) = \frac{n_C \times \sum_{i=1}^{n_C} (\bar{c}_i)^2 - (\sum_{i=1}^{n_C} \bar{c}_i)^2}{n_C^2 \times (n_C - 1)} \tag{21}$$

$\hat{Var}(\ \bar{c}_i\ )$ is the within day variance for counts and is estimated as:

$$V\hat{a}r(\bar{c}_i) = \frac{n_{C_i} \times \sum_{i=1}^{n_{C_i}} (c_{i,j})^2 - (\sum_{i=1}^{n_{C_i}} c_{i,j})^2}{n_{C_i}^2 \times (n_{C_i} - 1)} \tag{22}$$

Standard procedure has been to either have (most commonly) multiple counts on all days at a port within a month, or to have only one count per day. The software, however, was designed to deal with cases where there is one count on some days and multiple counts on others. In this case equation 20 is used if there are multiple counts on more than 40% of the days and equation 22 is used if there were multiple counts on less than 40% of the days. Existing documentation is unclear about how the single count days would be used in variance calculations when equation 20 is used and some days have only one count: either var($\bar{C}_i$) is treated as missing or as zero for those days.

Other measures of fishing effort (trips and days)

Angling hours are the basic measure of fishing effort used in Michigan's Great Lakes program. At times it is necessary to compare or combine these estimates with effort reported in units of days or trips. To this end effort estimates are also regularly reported in these units. Estimated effort in angler trips is given by:

$$\hat{E}_{trips} = \frac{\hat{E}_{hrs}}{\bar{e}_{CFP}} \tag{23}$$

with estimated variance:

$$V\hat{a}r(\hat{E}_{trips}) = \hat{E}_{trips}^{\ 2} \times [\frac{V\hat{a}r(\bar{e}_{CFP})}{\bar{e}_{CFP}^{\ 2}} + \frac{V\hat{a}r(\hat{E}_{hrs})}{\hat{E}_{hrs}^{\ 2}}] \tag{24}$$

where $\bar{e}_{CFP}$ is the mean trip length over interviewed people:

$$\bar{e}_{CFP} = \frac{\sum_{i=1}^{n_{CFI}} a_i \times e_i}{n_{CFP}} \tag{25}$$

with estimated variance:

$$\hat{Var}(\bar{e}_{CFP}) = \frac{n_{CFI} \times \sum_{i=1}^{n_{CFI}} (a_i e_i)^2 - (\sum_{i=1}^{n_{CFI}} a_i e_i)^2}{n_{CFP}^2 \times (n_{CFI} - 1)} \tag{26}$$

Equation 26 appears to be correct as written but software should be checked to verify that appropriate "n"'s are used.

Effort in days is calculated as:

$$\hat{E}_{days} = \frac{\hat{E}_{trips}}{\overline{t/a}_{FI}} \tag{27}$$

with estimated variance:

$$\hat{Var}(\hat{E}_{days}) = \hat{E}_{days}^2 \times [\frac{\hat{Var}(\overline{t/a}_{FI})}{\overline{t/a}_{FI}^{\,2}} + \frac{\hat{Var}(\hat{E}_{trips})}{\hat{E}_{trips}^{\,2}}] \tag{28}$$

where the average number of trips per angler over completed interviews is given by:

$$\overline{t/a}_{FI} = \frac{\sum_{j=1}^{n_{FI}} \frac{t_i}{a_i}}{n_{FI}} \tag{29}$$

with estimated variance:

$$\hat{Var}(\overline{t/a}_{FI}) = \frac{n_{FI} \sum_{i=1}^{n_{FI}} [\frac{t_i}{a_i}]^2 - [\sum_{i=1}^{n_{FI}} \frac{t_i}{a_i}]^2}{n_{FI} \times (n_{FI} - 1)} \tag{30}$$

and t_i indicates the number of trips the ith interviewed fishing party expected to complete that day.

Combining Harvest or Effort Estimates Across Strata

It is common to combine harvest and effort estimates across strata. For example, it is common to report effort and harvest for a month and port for both day types combined. Estimates for all modes combined and for combinations of ports and months are also made. To obtain estimates for these combinations, harvest and effort estimates and their estimated variances (from equations 1,2, 5-8, 23, 24, 27 or 28) are simply summed over the appropriate strata. The assumption that variances of a sum are equal to the sum of the variances requires that estimation errors be independent across strata.

Estimates of Harvest per Unit Effort

Reported estimates of harvest per unit effort are calculated either for individual strata or for strata combinations after the corresponding harvest and effort estimates have been made. Let $\hat{H}_{CS}$ and $\hat{E}_{CS}$ be the harvest and effort estimates for the particular combination of strata (which could be, but rarely is, a single stratum), then:

$$HP\hat{U}E_{CS} = \frac{\hat{H}_{CS}}{\hat{E}_{CS}} \tag{31}$$

with estimated variance:

$$V\hat{a}r(HP\hat{U}E_{CS}) = (HP\hat{U}E_{CS})^2 \times [\frac{V\hat{a}r(\hat{H}_{CS})}{\hat{H}_{CS}^2} + \frac{V\hat{a}r(\hat{E}_{CS})}{\hat{E}_{CS}^2}] \tag{32}$$

Evaluation of methods and estimates

Included with each reference is a partial abstract.

"Evaluation of Sampling Methodologies of the Lake Michigan Creel Survey", by Mary C. Fabrizio, James R. Ryckman and Roger N. Lockwood. Pages 162-176 *in* D. Guthrie, J. M. Hoenig, M. Holliday, C. M. Jones, M. J. Mills, S. A. Moberly, K. H. Pollock and D. R. Talhelm, editors. Creel and Angler Surveys in Fisheries Management. American Fisheries Society Symposium 12, American Fisheries Society, Bethesda, Maryland, USA.

> Abstract.-The Michigan Department of Natural Resources conducts creel surveys to characterize the Great Lakes sport fisheries and provide fisheries managers with information on catch composition, catch rates, and fishing pressure. Although data from the Lake Michigan creel survey have met a critical need in fisheries management, the present fiscal climate requires a more economical operation. We examined the current (stratified) design with respect to how reduction and pooling of sites would affect precision of catch rate and fishing effort estimates; in particular, we considered the feasibility of monitoring the fisheries by surveying three northern and four southern sites in Lake Michigan. Estimates of mean fishing effort were significantly different among sites considered for pooling. In general, the current sampling intensity permitted detection of a 30 or 50% change in fishing effort with at least 75% certainty for boat and pier fisheries but not for shore fisheries. Although trends in fishing effort at the southern sites were similar to those at northern sites, catch rates of the five major salmonid species varied between northern and southern sites. Recent declines in chinook salmon *Oncorhynchus tshawytscha* catch rates may have resulted in increased fishing for rainbow trout *O. mykiss*, lake trout *Salvelinus namaycush*, and coho salmon *O. kisutch* at the northern sites, and for coho salmon at the southern sites.

"A statistical comparison of catch per hour rates between complete and incomplete fishing trips in Michigan", by Roger N. Lockwood. Michigan Department of Natural Resources, Technical Report 84-2, 1984, Ann Arbor, Michigan, USA.

> Abstract.-Creel census data collected from Michigan anglers are frequently composed of complete and incomplete fishing trip interviews. The purpose of this study was to compare catch rates, by species, of complete and incomplete fishing trips. In each comparison, variance of catch rates were first tested to determine equivalency. The appropriate t test was then applied and statistical differences were determined, at the 5% level of significance. Data collected indicated that the catch per hour rates of incomplete trips were different from complete fishing trips more than 20% of the time.

"Refinement of creel census procedures", final report, study 521, by James R. Ryckman. Pages 211-225 *in* Michigan Dingell-Johnson Annual Reports, Projects F-35-R-9, Lansing, Michigan, USA.

> Abstract.-A computer program was developed to sample and make predictions from creel census data previously collected in the field. This program simulated both fishing pressure and catch rates for several types of fisheries. These types included a trout lake fishery, a trout stream fishery, a Great Lakes shore fishery, and three warmwater lake fisheries. The computer simulation program measured the effects of varying the angler interview rate from 2 to 90% of the total anglers upon the precision of the estimates as measured by their standard errors. The same tests were done to measure the effects of increasing the interviewing effort upon the bias of each estimate. The bias was defined as the difference between the point estimate and the actual parameter.
>
> One hundred replications of sampling effort were made for each level of interview rate and number of counts per day. Precision increased in all cases when the percentage of anglers interviewed was increased; but, the biases of these estimates did not decrease with increased interviewing effort.
>
> The decrease in the size of the standard errors of the estimates was not as great when the number of angler counts were increased as it was when the interview levels were increased. The bias factors of the estimates did not decrease when the number of angler counts per day were increased.

Quality control

Newly hired seasonal creel clerks are trained on-site by permanent fisheries technicians at the beginning of each field season. Also "training schools" have been organized during some years for all creel clerks. At these sessions training was provided on fish identification, form completion and biological data collection. Also, presentations about results from previous creel surveys and how those results are used to manage Michigan's Great Lakes fisheries were given at the creel clerk training sessions.

Count and interview forms completed by creel clerks are reviewed throughout the field season at the Charlevoix Fisheries Station prior to computer entry. Data are entered on the computer as they arrive throughout the season. Double entry of the data are not employed. The software used for data entry does employ range checking on various data fields for each count or interview record that was keyed. In addition, a module of the creel estimation software performed a final check of the data before catch estimates were made.

Creel forms

See appendix 4.

Recommended changes to creel survey

A brief listing of recommended changes to enhance Michigan's Great Lakes creel survey follows:

- Change to an area (statistical district) sampling strata from the present port system.
- Relieve creel clerks of their present biological sampling requirements and set up a system of bio-sampling teams.
- Estimate and report targeted effort for the salmonines species complex and for yellow perch and walleye.
- Estimate and report targeted catch rates for major species.
- Estimate the numbers of important species that are caught and released.
- Creel surveys of tributary streams are needed on a regular basis.

Creel survey contact personnel

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CREEL SURVEY OF THE WISCONSIN WATERS OF LAKE MICHIGAN

Geographic area

The geographical area of this survey is illustrated in Figure 1. Wisconsin's share of Lake Michigan is second only to Michigan and encompasses 495 miles of shoreline and 25 tributaries. The Wisconsin waters of Lake Michigan include Green Bay and portions of two distinct lake basins (northern and southern).

Green Bay is northernmost and more eutrophic than the lake proper and because of warmer temperatures during the summer, the majority of the salmonid fishery is limited to the northern section of the bay. Major access points include Marinette, Peshtigo and Oconto on the bay's west shore and Sturgeon Bay, Egg Harbor, Fish Creek and Ellison Bay on the east shore. A significant number of boats and anglers also fish from Green Bay, primarily for yellow perch and walleyes. Major tributaries include the Menominee, Little, Peshtigo, Oconto and Fox Rivers.

The northern basin extends from the tip of Door County to midway between Manitowoc and Sheboygan. The shoreline is generally rocky and irregular in the north and sandier and less broken in the south. The lake bottom slopes steeply to a maximum depth of 923 feet. Major access points include Gills Rock, Baileys Harbor, Sturgeon Bay, Algoma, Kewaunee, Two Rivers and Manitowoc. Major tributaries include the Ahnapee, Kewaunee, East and West Twin and Manitowoc Rivers.

The southern basin includes all waters from Sheboygan south. The shoreline is unbroken and the lake bottom slopes gently to a maximum depth of 558 feet. Major access points include Sheboygan, Port Washington, Milwaukee, Racine and Kenosha. Major tributaries include the Sheboygan, Milwaukee and Root Rivers.

Creel sampling dates

Year	Lake Michigan/ Green Bay Creel	Tributary Creel
1994	March 15 - October 31	March 1 - May 15 September 1 - December 31
1993	March 15 - October 31	March 1 - May 15 September 1 - December 31
1992	March 15 - October 31	January 1 - May 15 September 1 - December 31
1991	April 1 - October 31	March 1 - May 15 September 1 - December 31
1990	February 1 - November 15	February 1 - May 15 September 1 - November 15
1989	March 15 - November 15	March 15 - May 15 September 1 - December 31
1988	March 15 - November 15	March 15 - May 15 September 1 - December 31
1987	March 15 - November 15	March 15 - May 15 September 1 - November 15

1986	March 15 - November 15	March 15 - May 15 September 1 - November 15

Fishery types

The creel survey is conducted at ramp, pier and breakwater, shore and stream sites along Lake Michigan and Green Bay. Moored boat anglers are surveyed using a voluntary mail survey.

Creel survey sampling design

The open water creel survey was conducted using a modified access point design called the Wisconsin Hybrid design. It differs from a true access point design in that creel clerks visit several sites per site group. The fishing season for the creel survey is stratified by statistical management unit (SMU) (i.e. counties), fishery types (i.e. ramp, pier, shore and stream), statistical survey periods (i.e. months or groups of months) and day type (i.e. weekday, weekend/holiday).

Surveys were conducted on every weekend day and holiday and on either two or three days during the week, depending on the month. Each workday was comprised of two shifts, and am and pm shift. Combined together, the two shifts covered the entire angling day. The clerk worked one shift per workday. The shifts were equal in duration, did not overlap and were sampled with equal probability. An example is shown below.

Statistical Management Units (SMU) were assigned based primarily on county lines and include units like Kenosha, Racine, Milwaukee, etc. Survey sites within each SMU were placed into site groups. There may be one or several site groups in each SMU based on the time of year and size of each SMU. Site groups were selected randomly on a daily basis without replacement and survey sites within a site group were visited randomly.

For example, during an am shift, typically from 05:00 to 13:00 the clerk would be responsible for sampling two site groups (Milwaukee north and Milwaukee south). The clerk would spend half the shift in one group and the second half in the other group with the order determined randomly. A random count time would then be assigned to each group. The clerk would make instantaneous counts of all anglers or trailers at all sites in the site group. This means that only one count per site per day is made.

EXAMPLE

Statistical Management Unit	MILWAUKEE	
Site Groups	MILWAUKEE SOUTH	MILWAUKEE NORTH
Survey Sites	South Shore Ramps	McKinley Ramps
	South Shore Pier	McKinley Pier
	Oak Creek	Milwaukee River
	Grant Park Shoreline	Riverfront Ramp
	South Metro Pier	North City Shoreline

Angler contact methodology

Three types of data were collected for each site sampled: angler, boat trailer or car counts for effort, angler or party interviews for catch rates and biological information on harvested fish. Instantaneous counts were made by creel clerks at all sites in the survey. The type of count was dependent on the type of fishery. At most ramp sites, boat trailers were counted. At most pier, shore and stream sites, anglers were counted. However, due to poor access points on some tributaries, car counts were used and were corrected by the number of anglers in the car from interview data. The time the count was completed and count per site were recorded on the activity count form (Appendix 4).

Angler or angler parties were interviewed at the completion of their fishing trips. Anglers were asked if they were state residents, what time they started their fishing trip, what they fished for and the number of caught and harvested fish. These data were recorded on the angler interview form (Appendix 4). If the angler indicated that they had harvested fish, biological information such as species, length, weight, finclip and tag numbers were collected (Appendix 4).

Data collected

Data are collected on effort, targeted effort, harvest and catch. Fish are identified, weighed, measured and checked for finclips and tags. The biological data are summarized and presented in an annual creel report as follows: length and weight frequencies by species and SMU, mean, standard deviation, and range by species and SMU, and finclips by species, SMU and fishery type.

Effort, catch, CPUE and variance calculations

Fishing effort

Fishing effort estimates (expressed in angler hours) were derived from instantaneous counts of anglers at pier, breakwater, shore and stream sites and from counts of boat trailers at boat ramps and from counts of cars at stream sites. Counts were made at randomly computed times at each site during each visit. We estimated angler effort and its variance within each stratum (SMU, fishery type, month and day type). The variance of angler effort involves variability among days and variability within days. Formulas for two stage surveys were used to calculate variance.

The goal was to calculate total effort for a stratum (e.g. SMU, fishery type, month and day type) and its variance. First convert angler counts to angler hours by multiplying by the hours in the angling day. This requires that shifts were equal in duration, did not overlap and were sampled with equal probability.

n = number of days sampled
N = total number of days in stratum
m = number of instantaneous counts done per shift
M = number of instantaneous counts possible per shift
y_{ij} = angler hours for jth count on ith day

Calculate mean angler hours per day,

$$\bar{y}_i = \sum_{j=1}^{m} \frac{y_{ij}}{m}$$

and mean angler hours per stratum, (that is the mean of the daily means)

$$\bar{\bar{y}} = \sum_{i=1}^{\cdot\cdot} \bar{y}_i$$

calculate the pooled variance within days,

$$s_w^2 = \sum_{i=1}^{n} \frac{1}{n} \left[\frac{\sum_{j=1}^{m} (y_{ij}-\bar{y}_j)^2}{m - 1} \right]$$

and the variance among daily means,

$$s_b^2 = \frac{\sum_{i=1}^{n} (\bar{y}_i-\bar{\bar{y}})^2}{n - 1}$$

Using the symbols s_b^2 and s_w^2, we can write the formula for the variance of the mean daily angler hours within a stratum. Note that the following formula assumes that m << M (the number of instantaneous counts done was much less than the number that could potentially be done - this will usually be the case).

$$var(\bar{y}) = \frac{\left(1 - \frac{n}{N}\right)}{n} s_b^2 + \frac{1}{mN} s_w^2$$

If n/N is small, then we have

$$var(\bar{y}) = \frac{s_b^2}{n} = \frac{\sum_{i=1}^{n} (\bar{y}_i - \bar{\bar{y}})^2}{n\ (n - 1)}$$

Finally, total effort and variance within a stratum are

$$effort = N\ \bar{\bar{y}}$$

and

$$var(effort) = n^2\ var(\bar{\bar{y}})$$

Harvest and catch

Harvest and catch estimates were derived from interviews at anglers at all sites. For each interview, the number of fish harvested and the hours fished were determine. The harvest and hours fished were summed over all interviews in a stratum, the ratio of the sum and the variance of the ratio were then calculated.

i - indexes interviews
k = number of interviews
f_i = fish harvested, interview i
h_i = hours fished, interview i

R = harvest rate, fish harvested per hour fished

$$R = \frac{\sum_{i=1}^{k} f_i}{\sum_{i=1}^{k} h_i}$$

and

$$var(R) = \frac{1}{k} R^2 \left[\frac{var(f)}{\bar{f}^2} + \frac{var(h)}{\bar{h}^2} - \frac{2cov(f,h)}{\bar{f}\ \bar{h}} \right]$$

where $\bar{f}$ is mean fish harvested per interview, $\bar{h}$ is mean hours fished per interview and var(f), var(h) and cov(f,h) are the variance of fish harvested the variance of hours fished and the covariance between fish and hours respectively.

The harvest was then calculated as the product of effort in angler hours and harvest in fish harvested per hour. Variance was estimated as the variance of a product.

Y = estimated effort in angler hours
R = estimated harvest per hour
H = estimated total harvest

$$H = YR$$

and

$$var(H) = Y^2\ var(R) + R^2\ var(Y) - var(R)\ var(Y)$$

This assumes that effort and harvest rate were independent. Notice that the population formula (appropriate if all values are known, not estimated) involves a + (sum) where the above formula involves a - (difference). The above formula is correct when the terms in the product are estimated.

Moored boat survey design

Anglers who moored their boat on Lake Michigan and Green Bay but were not charter boat captains were surveyed by questionnaire beginning in 1988. The earlier surveys (1982-1985) were based on voluntary information from moored-boat owners who received their survey form from sport fishing clubs. However, in 1988, creel clerks were asked to compile a list of boat registration numbers of moored-boats present on Lake Michigan during a day of bad weather. These numbers were used to develop a list of boat owners from the Wisconsin Department of Natural Resources master file of registered boats. Beginning in 1988, a mail survey was sent to all moored-boat owners to obtain information on 1) whether they moored their boat on Lake Michigan or Green Bay; 2) the port of call; 3) whether the boat was used for fishing during that week; 4) the number of days fished; 5) number of anglers in the fishing party; 6) number of hours fished; and 7) the number of each species caught on each day during the past seven day period.

Effort, catch, CPUE and variance calculations

Fishing effort

Fishing effort was calculated by harbor by month for each month of the survey. Party size and number of hours fished on each trip were multiplied, summed for each month and harbor, and divided by the number of responses received for the month. This total was multiplied by the boat count and the number of days in the month to obtain estimated angler hours for the entire moored-boat population.

n = number of responses
p_i = party size, response i
h_i = hours fished, response i
C = number of boats counted
N = number of days in stratum

$$effort = \frac{\sum_{i=1}^{n} (p_i * h_i) * C * N}{n}$$

and the variance,

$$var(effort) = (C * N)^2 * (s)^2 * \frac{\left(1 - \frac{n}{C * N}\right)}{n}$$

Harvest

Harvest estimates were calculated by harbor by month for each species based on catch per boat day using the following formula:

H = harvest
i - indexes responses
f_i = fish harvested, response i
n = number of responses
C = number of boats counted
N = total number of days in stratum
s = standard deviation

$$H = \frac{\left(\sum_{i=1}^{n} f_i\right) * C * N}{n}$$

and the variance

$$var(H) = (C * N)^2 * (s)^2 * \frac{\left(1 - \frac{n}{C * N}\right)}{n}$$

Harvest rate

Catch rate, the number of fish caught per angler hour, was obtained by dividing the monthly reported catch of each species by the total fishing effort for that month for each harbor.

$$catch\ rate = \frac{H}{effort}$$

and the variance,

f_i = fish harvest, response i
f_{total} = summed harvest by stratum
h_i = angler hours, response i
h_{total} = summed angler hours by stratum

$$var(catch\ rate) = \frac{\left(1 - \frac{n}{C * N}\right) * \left[\sum_{i=1}^{n} f_i - \left(f_{total} * \frac{h_i}{h_{total}}\right)^2\right] * n}{(h_{total})^2 * (n - 1)}$$

This type of survey is biased because only those interested and successful anglers tend to mail back the survey form. Therefore, the harvest will tend to be an overestimate of the actual number but should be comparable among years and locations.

Evaluation of methods and estimates

The Wisconsin hybrid design has been used in Wisconsin for many years. Last year a Creel Survey Workshop was organized by the Bureau of Fish Management. As part of this workshop, a research statistician used creel data from Escanaba Lake in Wisconsin to show how the creel calculations were performed. These calculations were based on an inland creel program. I obtained this sample data set from this workshop and applied it to the Lake Michigan program. I calculated total effort and its variance, harvest and its variance, catch and its variance and harvest rates. In all cases the results were identical to the results obtained during the workshop.

Quality control

No regular scheduled checks were made on clerks prior to the 1995 fishing season. Starting in 1995, a separate clerk will check on the creel clerks to insure that they are on station and preforming their duties. This will be complemented with checks made by other field personnel who are engaged in field activities. Prior to 1995, creel clerks were checked on average 2 or 3 times per month by either permanent staff from Plymouth or Milwaukee. These checks were made both covertly and overtly. Several clerks were dismissed based on these checks in the last three years.

The clerks are initially trained by either a permanent fisheries technician or a former creel clerk. They spend 2 or 3 days at the start of the survey going over all the aspects of the creel survey. A check of the clerk is then made several weeks into the season to insure that all the correct information is being collected. Any problems that are noted during this visit or on data sheets are corrected at this time.

The data is entered by either the creel clerk or data entry personnel. The data entry program contains error checks so that all errors are detected before going into the permanent database.

Creel forms

Examples of the data sheets are shown in Appendix 5.

Recommended changes to creel survey

A brief listing of recommended changes to enhance Wisconsin's creel survey is shown below.

- Change current statistical management units to coincide with Lake Michigan statistical districts.
- Estimate and report targeted effort for salmonids, yellow perch and walleye
- Report harvest by length frequency for major species

Creel survey contact personnel

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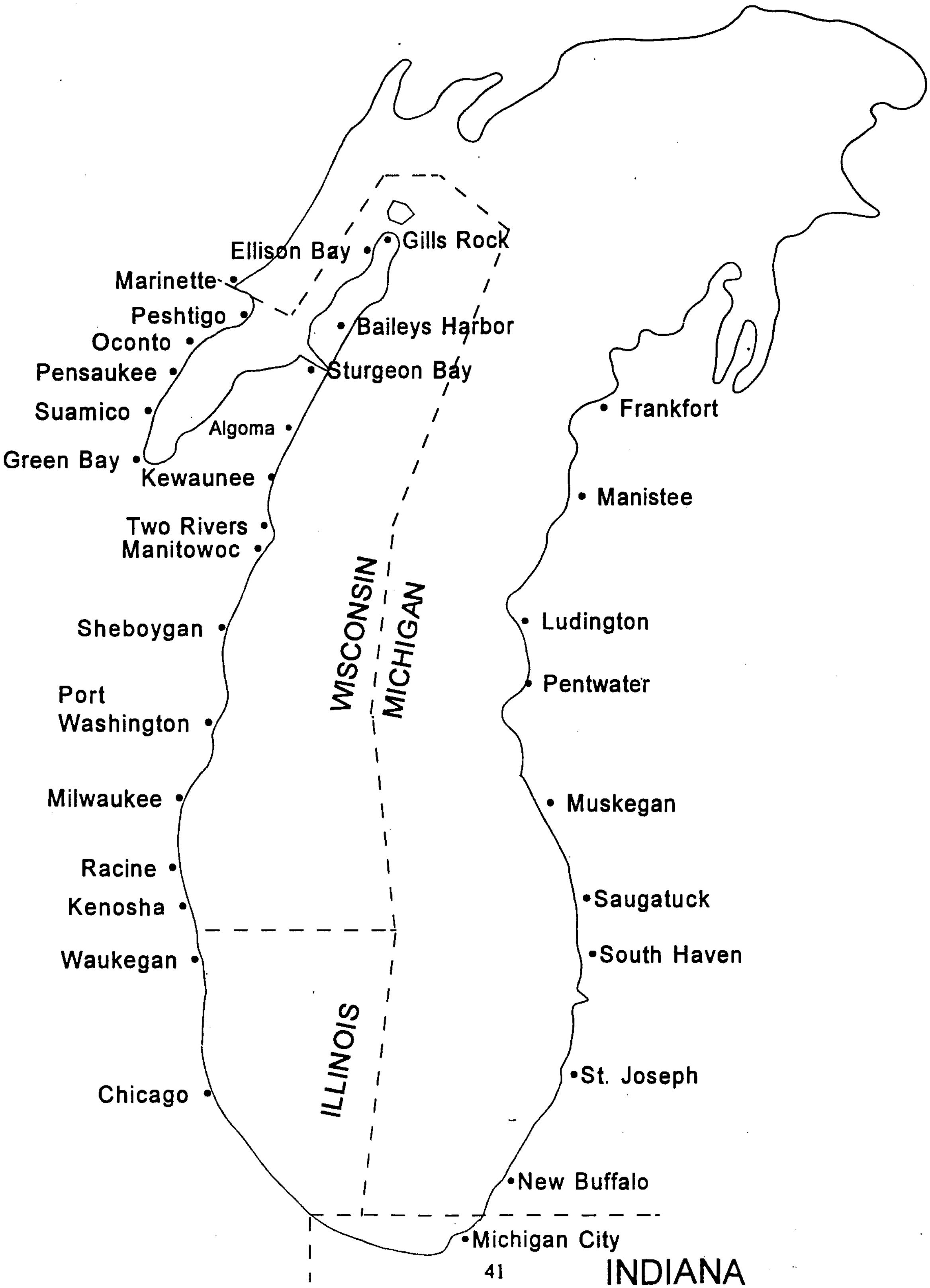
FIGURE 1 Geographical area of Lake Michigan.



APPENDIX 1 - Recommendations for estimation of harvest, effort and variances

At the initial meeting of the Lake Michigan Creel Survey Working group in January 1995, similarities in survey design and differences in methods used to calculate estimates were discussed. The surveys conducted by each of the states were described as "stratified random designs." We also noted that in each jurisdiction harvest estimates were made by multiplying an estimated harvest rate (numbers of fish of a specified type per angling hour) by the total angling hours for a defined stratum. For each state we listed the stratification variables as time period (month or similar interval), day type (weekday or weekend/holiday), fishing mode (e.g., boat, pier, shore etc.) and area (e.g., port or management area). We agreed that additive estimates of harvest and effort should be made on a monthly basis by statistical district, day type and fishing mode. Because of the apparent similarities in survey design among jurisdictions, and differences in existing methods used to estimate harvest rates, standardization of estimation methods was viewed to be both feasible and desirable. This report explores possibilities for such standardization.

Two facts made the preparation of this report more involved than was originally expected:
1) The survey designs do not follow a true stratified random design.
2) The survey designs differ from one another in subtle but important ways.
Hence, I first review similarities and differences in sampling designs and current estimation calculations used by the four jurisdictions. I then make recommendations for changes in the way calculations are done.

The intent of these recommendations is to identify potential ground for standardization and improvement. All recommendations made here are provisional, pending both review and test applications. Furthermore, although some room for standardization and improvement is noted, methods currently used in all jurisdictions are reasonable solutions to the complex task of estimating sport fishing harvest and effort.

Similarities and Differences in Survey Designs

All the Lake Michigan creel survey designs approximate a two-stage sampling design for individual sites or areas, with days (or days crossed with shifts) as the first-stage sampling units (clusters). Second-stage sampling units are specific time of day (for counts) or individual interviews (for interviews).

For all the Lake Michigan creel surveys, not all sites are sampled on all days and during all time periods within days. The subset of days and portions of days that a specific location is sampled within a longer time period (generally a week) and day-type category (weekdays versus weekends/holidays) is selected with some degree of randomness.

Each of the creel surveys uses a variant of an access site method. Most discussions of access site creel survey designs assume that during a period a site is sampled all anglers leaving the access point are interviewed, or that at least all anglers leaving a site are counted (e.g., Pollock et al. 1994). This is not the case for the Lake Michigan creel surveys. When a sampler is assigned to a site, the site tends to be too large, sometimes with more than one access, so not all anglers can be counted or interviewed. Generally a sampler will tour the site, attempting to intercept and interview as many anglers as possible. Although the anglers or angler groups that are interviewed at a site on a given day or portion of a day do not constitute a true random sample, it is pragmatic to treat them as though they were.

Counts of anglers are then made separately either by making interval counts at each access or through instantaneous counts of boats in the water or trailers, cars or pedestrian anglers.

There are also important differences in designs. The states differ in how the individual days or days x shifts are selected. Indiana and Illinois use a similar approach that contrasts with that used in Wisconsin and Michigan. In both Indiana and Illinois there is only one set shift and each site is sampled on one randomly selected weekday and weekend day during each week. The days individual sites are selected are not independent because each sampler can only sample one location at a time.

In Wisconsin an individual sampler will usually be responsible for sampling two site groups, either within a single statistical management unit (SMU), or composing two SMUs. The sampler will collect samples on all weekend days and two to three randomly selected weekdays. Once the sampling days are selected either an AM or PM shift is selected randomly. The two site groups to be sampled during a given day are then selected randomly without replacement within the day. Thus, each sample day a sampler covers all sites in the SMU, with random selection determining the order they are visited.

In Michigan, individual samplers are generally responsible for two sites (ports) and sample only one site on a given day. Both weekend days are sampled and three weekdays each week. Two consecutive "pass" days are selected by selecting randomly from all possible such pairs of days. Once sampling days are selected, an AM or PM shift is assigned randomly, and then the port to be sampled is selected randomly. The monthly schedule is then examined and if either one shift or port is being sampled much more than the other the schedule is adjusted so that sampling is more equal in the two.

Selection of count times also differs among the states. Indiana makes a count every hour with the time within the first hour selected randomly. In Illinois counts are made before and after interviews at each site. In Wisconsin, counts are generally made once each day at each site. In Michigan counts are generally made during two randomly selected time blocks within a shift.

The states also differ in how interviews are selected. In Wisconsin and Michigan interviews are almost entirely of angling parties that have completed fishing trips. In Illinois and Indiana sampling occurs for incomplete trips (largely for shore and pier fishing).

Brief Summary of Current Estimation Methods

For the purposes of estimation all jurisdictions stratify data similarly. Data are grouped by day type (weekend/holiday or weekday), fishing mode, month or similar time period, and area or site. The approach for estimating fishing effort in angling hours is essentially the same in all jurisdictions. The average count on each sampled day is converted to angling effort in hours and then the average daily effort for the estimation stratum is calculated. This is then scaled up to total effort by multiplying by the number of days.

Michigan, Indiana and Wisconsin use the same basic logic for estimating harvest within an estimation stratum. In each, harvest rate (fish per angling hour) is calculated for the stratum and is multiplied by the stratum estimate of effort. Indiana and Wisconsin calculate the harvest rate by summing up the harvest for interviewed anglers and dividing this by sum of the effort for the interviewed anglers. In Michigan, a harvest rate is calculated for each angling party and then the average for the stratum is calculated.

In Illinois a harvest estimate is made for each sampled day and an average daily harvest for the stratum is calculated. Total stratum harvest is this average multiplied by the number of days. The harvest estimate for an individual day is made by multiplying the harvest rate for that day by the effort for that day. The harvest rate (for the day) is calculated in the same fashion as stratum harvest rates are in Wisconsin and Indiana.

Variance estimates are calculated only by Michigan and Wisconsin. Although the calculations differ substantially in detail between these states, they follow similar logic. In both states, variances are estimated for the stratum harvest rate and effort estimates and then the variance for the harvest estimate is based on a formula for the variance of the product of two random variables. In the calculation of variance for harvest rate, both states treat each individual interview within the estimation stratum as an independent replicate. In calculation of variances for effort, both states treat the effort data as coming from a two-stage design, with sample days within estimation strata being the first-stage sampling units (clusters), and counts within days the second-stage units.

Proposed Approach

I start by making recommendations on estimating effort and harvest, then turn to estimation of variances. For states that allocate a specified amount of sampling effort to a site or specific area each week (all but Michigan), I recommend estimating effort and harvest first for each sampled cluster, then expanding this to the week, and finally summing up weekly estimates to get estimates over longer time periods. Monthly estimates could be derived by apportioning the appropriate fraction of the harvest or effort for weeks that are split between months. In Michigan, where allocation of sampling to a port is set by schedule adjustment on a monthly basis, estimates should be made for each cluster and then expanded to the month. Thus the season should be viewed as stratified into weeks in Illinois, Indiana and Wisconsin, and into months in Michigan.

If the sampling frame (all possible clusters that might be sampled) for a stratum consists of K clusters, k of which are sampled, and the estimated value (either harvest or effort) for the ith cluster is $\hat{Y}_i$, then the stratum total would be:

$$\hat{Y} = \frac{K}{k} \sum_{i=1}^{k} \hat{Y}_i \tag{1}$$

In some cases this estimate would need to be expanded further to account for time or locations not included in the sample frame.

I recommend that harvest for a cluster be calculated as the product of harvest rate (fish per hour) and angler effort in hours for that cluster. Effort for the cluster can be calculated much the way it is now done by each state. The calculations depend on whether counts are instantaneous or interval. For instantaneous counts effort can be estimated as the product of the average count, mean number of anglers per party and number of hours in the cluster. For interval counts it can be estimated as the product of the mean count, mean number of anglers per party, mean trip length and number of hours in the cluster.

The way the cluster harvest rate is calculated should depend upon whether complete or ongoing trips are sampled. When interviews are primarily complete trips (Michigan and Wisconsin, or boat fisheries in Indiana and Illinois), harvest rate should be calculated by first summing harvest and effort over all interviews, then dividing the summed harvest by the summed effort. When interviews can be considered a random sample of ongoing fishing trips (Indiana and Illinois shore/pier fisheries), harvest rates should be calculated for each interview and then averaged.

Basis for Proposed Approach

The proposed approach is in better agreement with the existing survey designs than current estimation methods that are used in Michigan, Indiana or Wisconsin. It differs only slightly from the approach currently used in Illinois. The current practice of pooling data into monthly (or similar time blocks) ignores potential gains from the within month stratification, and when harvest rates are calculated on a monthly basis potential for significant bias is introduced. Such bias can occur if daily effort is related in some way to daily harvest rate and sampling is not strictly proportional to effort. In general, proportional sampling does not occur in the Lake Michigan creel surveys because samplers become "saturated" when effort is high. In other words, the current approach assumes self weighting (e.g., Cochran 1977), which is unlikely.

There are at least three intuitively appealing estimators of (cluster) harvest:

$$\begin{aligned} H_i &= R1_i \times E_i \qquad (a) \\ H_i &= R2_i \times E_i \qquad (b) \\ H_i &= \bar{h}_i \times T_i \qquad (c) \end{aligned} \tag{2}$$

where

$$R1_i = \frac{\sum_{j=1}^{n_i} h_{ij}}{\sum_{j=1}^{n_i} e_{ij}} \; , \qquad R2_i = \frac{\sum_{j=1}^{n_i} \frac{h_{ij}}{e_{ij}}}{n_i} \; \text{and} \qquad \bar{h}_i = \frac{\sum_{j=1}^{n_i} h_{ij}}{n_i} \tag{3}$$

In the above, n_i is the number of interviews in the ith cluster, h_{ij} is the harvest for the jth interview of the ith cluster, e_{ij} is the effort in hours for the ith interview in the jth cluster. T_i is an estimate of the number of trips in the ith cluster and E_i is the estimated effort in hours for the ith cluster.

Estimators a and b are based on the idea that if we knew the ratio of the total harvest to the total effort and the total amount of effort, we could multiply the ratio by total effort to find total harvest. The choice between R1 and R2 is not a trivial one, because for the same data set the two estimators can produce substantially different estimates. For example, Crone and Malvestuto (1991) show examples where the estimates for these two methods differ by about a factor of two in Alabama reservoirs. R1 has the form of a standard ratio estimator widely used in sample survey estimation, and this estimator is widely used in creel survey work (Malvestuto 1983, Pollock et al. 1994). Standard formula for the variance of H cannot be directly applied because they assume that E is known rather than estimated. The sampling properties of R1 and appropriate variance estimators are, however, well known. In general, R1 is a biased estimator of the population ratio of harvest to effort, but becomes the best linear unbiased estimator for the special case where the relation between h and e is a straight line through the origin and the error variance for h about the line is proportional to e (Cochran 1977). This estimator is consistent in that it approaches the correct answer for large sample sizes, provided angling parties are sampled at random. Intuition suggests that this would be the case: we are estimating the ratio of the sum of the harvest over the sum of the effort by the ratio of these same two quantities for a sample of the anglers.

Estimator b is not much discussed in standard sampling texts. It is discussed to a limited extent by Malvestuto (1983) and Pollock et al. (1994). R2 is known to be a biased estimator of the population ratio, and does not generally approach the correct answer for large sample sizes. This is an unbiased estimate of the population ratio for the same special cases where R1 is unbiased. Some unbiased variants of estimator b have been suggested, but are not widely used because they are known to be highly inefficient. Pollock et al. (1994) refer to an unpublished manuscript by Robson and recommend estimator b over estimator a in situations where interviews occur during rather than after fishing, and this is the basis of my recommendation for its use. This recommendation was based on theoretical considerations rather than examination of how the estimator performed in simulations. This recommended procedure will tend to counterbalance the fact that longer trips are oversampled when ongoing trips are sampled (this is a violation of the random selection of angler parties assumption).

Estimator c has the form of a standard "mean per unit" estimator, which is widely used and discussed in sampling texts (e.g., Cochran 1977). Here it is only applicable for cases where interviews are for complete trips. Again, its sampling properties cannot be derived directly from standard results because these assume that T_i is known rather than estimated. $\bar{h}_i$, however, is known to be an unbiased estimate. Whether estimator a or c should be selected depends upon characteristics of the data. In particular, estimator a tends to be more efficient when h_{ij} and e_{ij} are more strongly correlated. In the case where E_i or T_i is known, estimator a has a lower variance than estimator c when this correlation is greater than the coefficient of variation of e_{ij} divided by twice the coefficient of variation of h_{ij}. In cases where H and T are estimated, this result would tend to translate provided H and T are equally well estimated. Estimator a is more commonly used in creel surveys than is estimator c. This is probably because trip length is generally assumed to contain information regarding the magnitude of harvest, which is the intuitive interpretation of the efficiency condition. I recommend estimator a be used for surveys restricted to complete trips because it is consistent and under reasonable conditions efficient, and because it is widely used in other creel surveys. Estimator c could be used instead of estimator a, and this would be warranted if the correlation between h_i and e_i was weaker than the condition specified in the paragraph above. A more definitive recommendation is not possible without analysis of data.

Variance Calculations

Recommendations regarding estimating variances for harvest and effort are complicated by systematic sampling, lack of replication, and differences among jurisdictions. I begin by describing how variances could be calculated in the absence of such complications for a two-stage sampling design, and then deal with the complications on a state-specific basis.

The usual steps involved in calculating variances for a two-stage sampling designs involve first estimating the variances of the individual H_i and E_i to estimate the within cluster (day or day x shift) variance, estimation of the between cluster variance, and combination of the between and within cluster variances. I will assume that the number of randomly selected samples within a cluster is small relative to the cluster size so that finite population corrections can be ignored at the second stage of sampling. In what follows there are K possible clusters in the stratum and we are sampling k of them. We are estimating the stratum total Y, and the total for a cluster is Y_i. Y here could refer to either effort or harvest, and the estimated variance of its estimate is:

$$\hat{var}(\hat{Y}) = \frac{K^2\left(1-\frac{k}{K}\right)}{k} s_b^2 + \frac{K}{k}\sum_{i=1}^{k} \hat{var}(\hat{Y}_i) \qquad (4)$$

s_b^2 is the between cluster variance estimate and is given by:

$$s_b^2 = \frac{k\sum_{i=1}^{k} \hat{Y}_i^2 - \left(\sum_{i=1}^{k} \hat{Y}_i\right)^2}{k(k-1)} \tag{5}$$

When k/K is small, then variance can be approximated by:

$$v\hat{a}r(\hat{Y}) = \frac{K^2}{k} s_b^2 \tag{6}$$

This is a conservative estimate, in that it will overestimate the variance for k/K>0, and to a greater degree as k/K increases (see Cochran 1977, Section 10.4, page 279 and Hoenig et al. 1993).

To apply the above equations we need to obtain values for E_i, H_i and estimates of their variances. E_i can be estimated as the product of the average count, mean number of anglers per party and number of hours in the cluster for instantaneous counts. For interval counts it can be estimated as the product of the mean count, mean number of anglers per party, mean trip length and number of hours in the cluster. The estimated variance for E_i, $v\hat{a}r(E_i)$ is then obtained by repeated applications of rules for obtaining the variance of two random variables and the variance of a constant times a random variable.

The estimated variance of a constant, c, times a random variable (estimated quantity), $\hat{a}$, is given by $v\hat{a}r(c\hat{a}) = c^2 v\hat{a}r(\hat{a})$. I recommend estimating the variance of a product of two independent estimates by:

$$v\hat{a}r(\hat{a}\hat{b}) = \hat{a}^2 v\hat{a}r(\hat{b}) + \hat{b}^2 v\hat{a}r(\hat{a}) - v\hat{a}r(\hat{a})\ v\hat{a}r(\hat{b}) \tag{7}$$

There is some confusion in the literature regarding the appropriate way to estimate this variance. Both Wisconsin and Michigan currently use a product rule to estimate variances of products (assuming independence), but use different versions. For two estimated values, $\hat{a}$ and $\hat{b}$, Michigan estimates variance of $\hat{a}\hat{b}$ as $\hat{a}^2 v\hat{a}r(\hat{b}) + \hat{b}^2 v\hat{a}r(\hat{a})$. Wisconsin uses equation 7. The formula used by Michigan is a longstanding approximation (e.g., Kendall and Stuart 1964). Pollock et al. (1994, page 222) recommend estimating the variance of the product by: $\hat{a}^2 v\hat{a}r(\hat{b}) + \hat{b}^2 v\hat{a}r(\hat{a}) + v\hat{a}r(\hat{a})\ v\hat{a}r(\hat{b})$, which differs from both the Michigan and

Wisconsin formulas, and refer to Seber (1982). Seber presents this equation as the exact formula for the variance of a product in the form var(ab) = $E(a)^2var(b) + E(b)^2var(a) + var(a)var(b)$, with a reference to Goodman(1960). Finally, Goodman (1960) derives the formula presented by Seber, but also shows that when E(a), E(b), and their variances are estimated, an unbiased estimate of the variance of the product is given by equation 7.

Some of the quantities being multiplied together may not be independent, a requirement of equation 7. For example mean trip length and mean number of anglers per party will most usually come from the same interviews. One way around this difficulty is to calculate the product of trip length and number of anglers on an interview by interview basis to obtain the hours per interview, and use the mean of this product instead of the product of the means in the calculations. The variance of the mean product is then estimated using the standard formula for the sample variance of a mean of a random sample:

$$\hat{var}(\bar{y}) = \frac{\sum_{i=1}^{n}(y_i-\bar{y})^2}{n(n-1)} = \frac{n\sum_{i=1}^{n}y_i^2 - \left(\sum_{i=1}^{n}y_i\right)^2}{n^2(n-1)} \tag{8}$$

This same equation is used to obtain variances for other mean values, when finite corrections can be ignored.

Cluster harvest, H_i, is estimated as R_iE_i, where R_i is one of the two estimators of harvest rate described earlier. We obtain an estimate of the variance of H_i by first estimating the variance of R_i (and E_i) and then applying the product rule described above. In the case of incomplete trips, R_i is an average and its variance can be calculated using the equation for the sample variance of a mean given above. In the case of complete trips, the estimated variance of a ratio of sums (or equivalently the ratio of means) needs to be calculated (dropping the subscript for days):

$$\hat{var}(\hat{R}) = \frac{s_h^2 + \hat{R}^2 s_e^2 - 2\hat{R}s_{he}}{n\bar{e}} \tag{9}$$

(Cochran 1977, page 155, equation 6.13), where n is the number of interviews in the sample, s_h^2 and s_e^2 are the sample variances of harvest and effort on interviews and s_{he} is their sample covariance. The sample variance for harvest is:

$$s_h^2 = \frac{\sum_{j=1}^{n}(h_j-\bar{h})^2}{n-1} \tag{10}$$

The sample variance for effort is calculated in the same way and the sample covariance is:

$$s_{he} = \frac{\sum_{j=1}^{n} (h_j - \bar{h})(e_j - \bar{e})}{n-1} \tag{11}$$

State-specific recommendations

Wisconsin samples each site on each sample day leading to two weekend samples and two or three weekday samples each week. This should allow variances to be calculated for each weekend or set of weekdays forming a stratum. A cluster consists of the half-shift a particular site is sampled. Consequently, 25% of the available clusters are sampled on weekends and 10-15% of them are sampled on weekdays. Because generally only one count is done for each area on a sample day, it is not possible to calculate a within cluster variance for effort or consequently for harvest. The conservative approximation (equation 6) needs to be used. Effort for a cluster (E_i) needs to be calculated to reflect the quarter of a fishing day it represents.

In Michigan each month can be viewed as a temporal stratum and there are generally replicate clusters within the month, allowing the calculation of variance. A cluster consists of a shift, and although shifts overlap, the times counts are done do not. A cluster should be viewed as reflecting half a fishing day. Within a cluster there are replicate (usually two) counts, so within cluster variance can be calculated and equation 4 can be used.

Indiana samples a single shift that does not cover the fishing day. Calculations should initially be done for the portion of the fishing day that is sampled (i.e., E_i represents the effort in that period) and then expanded using an adjustment factor to cover unsampled hours. Although hourly counts are made, they cannot be used to calculate variances for the E_i because they are timed at systematic intervals. Each site is sampled only once each weekend and on one weekday each week, precluding the calculation of variance using equation 6 (or 4) directly. One possible solution is to estimate s_b^2 by treating observations over a two week or longer (say a month) period as though they were in a single stratum. This will overestimate variance to the extent that observations within a week are likely to be more similar than randomly selected clusters within a longer period. Cochran (1977) describes more involved procedures (section 5A.12) that might be adapted.

Indiana calculates harvest separately for yellow perch and salmonines using targeted effort. This procedure is somewhat nonstandard. For example Neuhold and Lu (1957) and Malvestuto (1983) both point out that calculations use total effort, and although this may produce a high variance for the harvest rate, the resulting harvest estimates can be efficient. It is not clear whether or not poststratifying by effort type would improve estimates because now the fraction of angling hours falling into each type of fishing needs to be estimated. Because the practice is not widely used and has unknown properties I cannot recommend it until its effects are investigated.

The situation in Illinois is similar to that in Indiana. Although several sites are sampled on a given day, each site is always sampled during a fixed time period of the day. Hence each site can be viewed independently as having a sample frame covering a relatively small portion of the day. Also, like Indiana, replication does not generally occur within weeks. Although there are two counts for each site sampled on a day, these are not selected randomly in time. Because the period involved is not as great as in Indiana, use of these values to calculate within cluster variances may not excessively overestimate the true within cluster variances. As in Indiana, the between day variance within a week may need to be approximated using data from a longer time period. It appears that either equation 4 or 6 would be conservative and I recommend experimentation to determine which produces smaller values. Perhaps the greatest source of uncertainty in Illinois will be in expanding from the sample period to the entire fishing day, and this uncertainty is not incorporated into any of the variance calculations.

General and Summary Comments

1. All the recommendations in this document should be considered provisional. They are based upon a review of the existing sampling designs and literature on sampling designs and creel surveys. The feasibility and value of a method do not, however, always become apparent until it is tried. For example, calculation of harvest rates on a cluster by cluster basis is theoretically justified, but could potentially inflate variances causing a bigger problem than the one it is designed to avoid. Close communication among the Lake Michigan states' creel survey programs will facilitate the practical evaluation of the methods recommended here.

2. The estimates of variances should all be considered approximate. In some cases there are approximations involved in their derivation and in every case the survey designs only approximately match the assumptions called for. For example, we assume that interviews are selected at random from the population of fishing parties in a cluster. In fact, interviews are spread out over a work day, and tend to be clustered spatially within the work day. These will have an unknown impact on the accuracy of variance estimates. Another example is where we summarize estimates by summing harvest and effort estimates and their variances across strata. This is correct provided the sampling in different strata is independent. For the actual designs used on Lake Michigan, however, the selection of clusters in one stratum depend upon the selection in another. For example, if a single creel sampler is responsible for two spatial strata, they will not both be sampled at the same time and this will tend to set up a negative covariance. The effect of this is likely to make our estimates of variances of sums larger than they really are. It is common practice to transform variance estimates into confidence intervals. This too involves an approximation, where we assume that our estimated quantities are normally distributed.

3. As the states consider redesign of the Lake Michigan Creel surveys, efforts should be made to include as much of the population of interest (the entire fishing day at all fishing sites) within the sampling frame. This would reduce the need for tenuous extrapolations. This need not involve an increase in sampling effort, but may mean that less detailed information about particular sites will be collected.

4. All estimates should be reported with associated estimates of uncertainty. These should include variance estimates, but should also include information on just how far the estimates are extrapolated. Most estimates require some expansion to unsampled times and places. I recommend that we include with reported estimates the percentages of the associated estimates of fishing effort that were covered in the sampling frame. For example, if we estimate fishing activity in a region that occurs over a 14-hour day from a 6 a.m. to 1 p.m. sampling period and from samples selected from a subset of sites in the region, we might need to multiply harvest estimates for the sampled sites and time period by a correction factor of two because only half the total fishing effort occurred at times and sites potentially sampled by the survey. I think that we should report this 50% coverage of the effort along with our other estimates. It may be that we will treat these calibration factors as constants in calculations of variance, but the fact that greater uncertainty is present for estimates requiring more extrapolation could be communicated in this way.

5. Many open questions remain, many of which have been discussed in this report. A number of these questions relate directly to the efficiency of creel survey programs in terms of both design and analysis. Many of these questions can be explored through analysis of existing data. The states are encouraged to take advantage of the valuable resource represented by existing creel survey data during the process of redesigning aspects of the Great Lake Creel Survey.

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ILLINOIS NATURAL HISTORY SURVEY
Lake Michigan Biological Station

1995 CREEL SCHEDULE

10 July - 30 July

Segment 6

DATE	Lake County	North Chicago	Central Chicago	South Chicago
Mon 10:		x		
Tue 11:				x
Wed 12:	x			
Thu 13:			x	
Fri 14:	*(no creel)*			
Sat 15:		x	x	
Sun 16:	x H M			x
Mon 17:				x
Tue 18:		x		
Wed 19:	x			
Thu 20:	*(no creel)*			
Fri 21:			x	
Sat 22:		x	x M	
Sun 23:	x H			x
Mon 24:		x		
Tue 25:	*(no creel)*			
Wed 26:			x	
Thu 27:	x			
Fri 28:				x
Sat 29:		x M	x	
Sun 30:	x H			x

REMARKS:
In addition to interviewing anglers at the North and Central Chicago clusters, there is a helicopter flight scheduled for aerial census of pedestrian anglers and boat trailers on Sat., 15 July. Departure time from Waukegan Airport is 0800 and the flight lasts approximately 2.5 hours. Volunteers for the flight are W. Brofka and ________.

The next creel meeting will be ____________________ at ___________ unless posted otherwise.

WB: Rev. 03/17/95

PAGE ________ OF ________

SITE DATA	TIME	REGULAR PEDS			SPECIAL PEDS			TRAILERS
		HAR	SHO	STR	SNA	SMT	ICE	
START								
FINISH								

Reporter ________________ Location ______________________________

DATE ___ ___ ___
M D Y

PARTY RECORD															CATCH RECORD											
ID	ANGLER TYPE (CIRCLE ONE)	# ANGS		# LINES		# NETS			TRIP TIMES			EXPENSES														
		TOT	RES	ROD	PWR	GILL	DIP	SEINE	BEGIN	INTER-VIEW	END	MAJ	MIN	OTHER	SOUGHT	BK	BN	RB	CO	LT	CH	YP	SM	WP	OTHER	#FLOY TAGS ON YELLOW PERCH
	HAR SHO STR LAU SNA SMT ICE MOO																									
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TIME (start time of interview set): ____________________

FISH RECORD							
ID	Species	Weight (g)	Length (cm)	Clipped Fins/Tag #	# Scars	# Wounds	Notes

FISH RECORD							
ID	Species	Weight (g)	Length (cm)	Clipped Fins/Tag #	# Scars	# Wounds	Notes

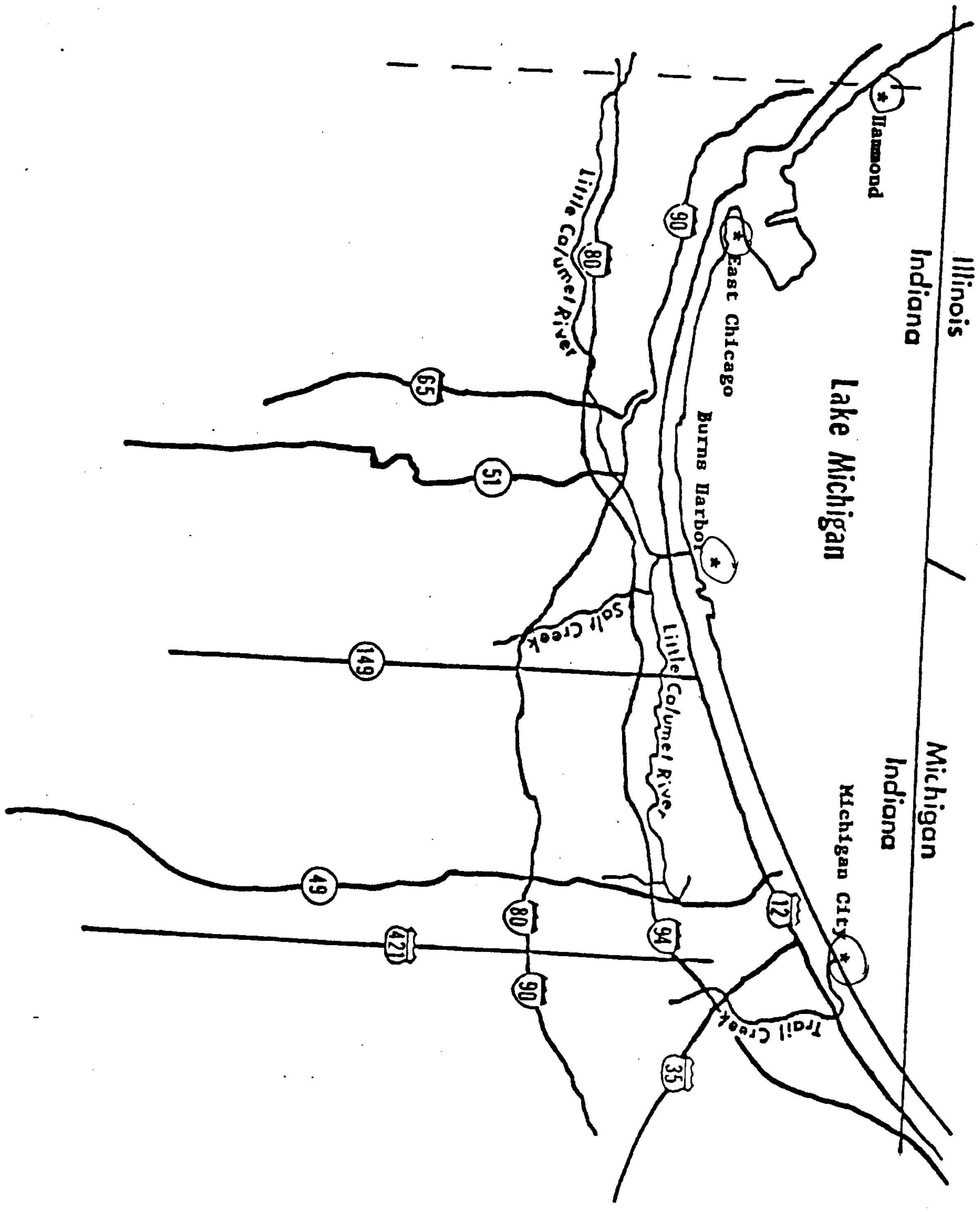


Figure A. Creel survey sites along the Indiana shoreline of Lake Michigan.

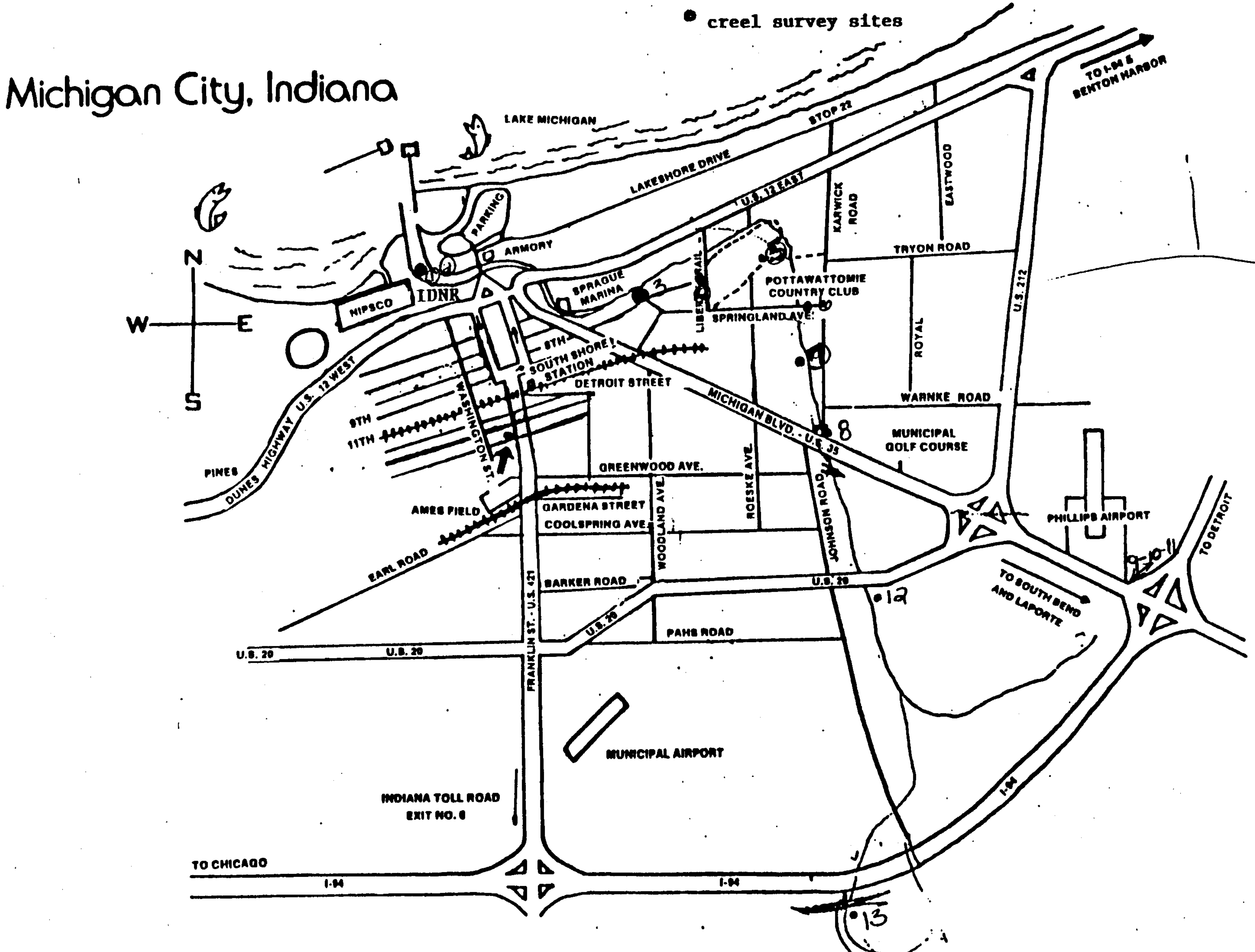


Figure B. Creel survey sites along Trail Creek. Michigan City, Indiana.

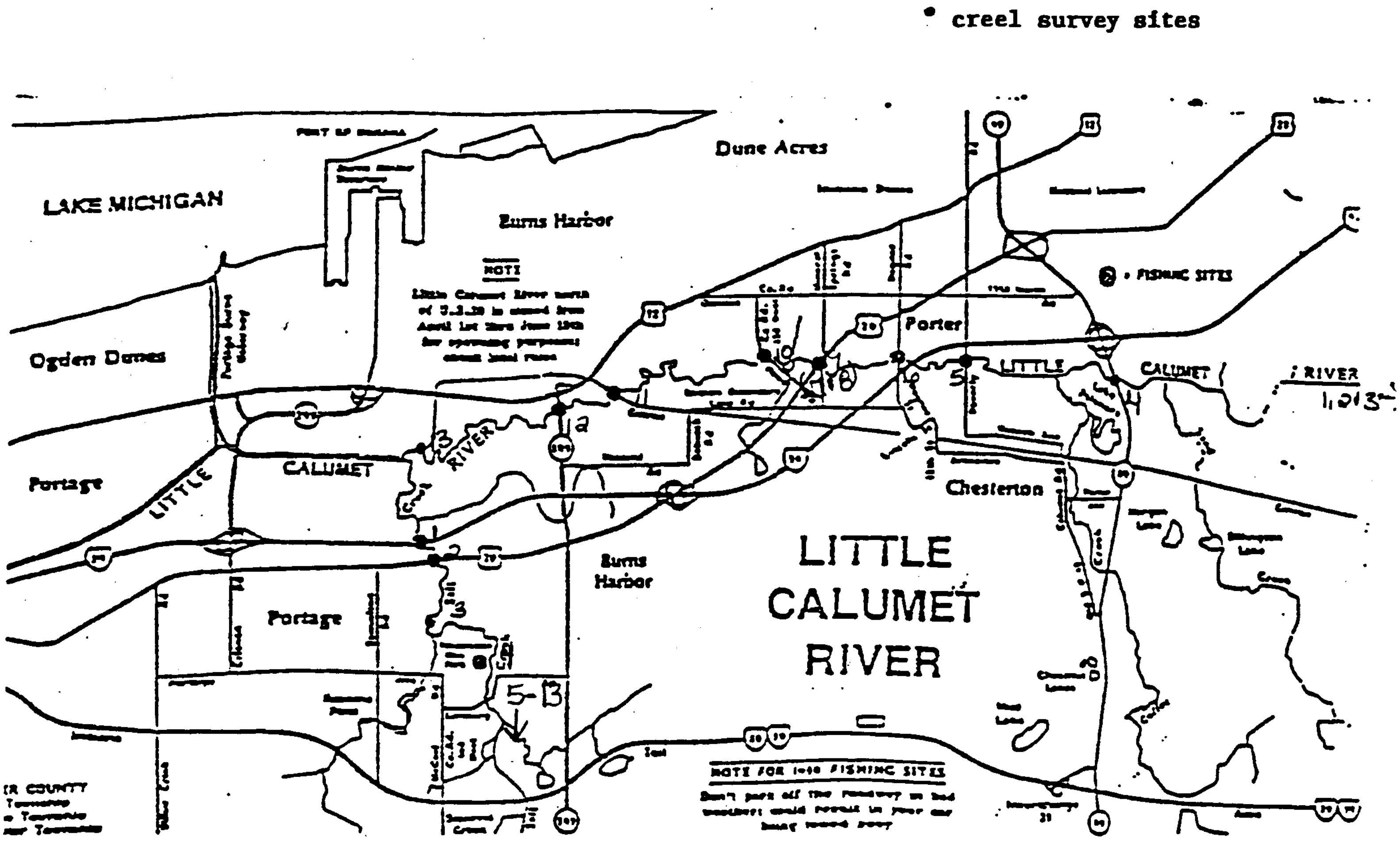


Figure C. Creel survey sites along Little Calumet River and Salt Creek.

IDNR **Lake Michigan Investigations**

Stream Fishermen Vehicle Counts

A.M. or P.M.

Stream: **TC** Date __ /__ /__ Weekend or Weekday Clerk ____

WEATHER:

Average temperature ___ Stormy __.__ hours

Average sky: sunny hazy p. cloudy m. cloudy overcast

Precipitation (% of time that it rained): 0 25 50 75 100

Stream height: flooded high normal low

Stream water clarity: low (muddy) fair high (clear)

Sites	Count 1 __:__ - __:__	Count 2 __:__ - __:__	Count 3 __:__ - __:__
DNR A (anglers) (1)			
DNR_B (boats) (2)			
RR (3)			
LT (4)			
FG (5)			
SP (6)			
KA (7)			
35 (8)			
PA (9)			
ME (10)			
DD (11)			
20 (12)			
JR (13)			
TOTALS - (RR–JR)			

Notes:

IDNR Lake Michigan Investigations

Stream Fishermen Vehicle Counts

A.M. or P.M.

Stream: LC Date __ /__ /__ Weekend or Weekday Clerk ____

WEATHER:

Average temperature ___ Stormy __.__ hours

Average sky: sunny hazy p. cloudy m. cloudy overcast

Precipitation (% of time that it rained): 0 25 50 75 100

Stream height: flooded high normal low

Stream water clarity: low (muddy) fair high (clear)

Sites		Count 1 __:__ - __:__	Count 2 __:__ - __:__	Count 3 __:__ - __:__
600	(1)			
450	(2)			
BR	(3)			
49	(4)			
CA	(5)			
SE	(6)			
WAV	(7)			
WAG	(8)			
20	(9)			
HO	(10)			
149	(11)			
MG	(12)			
MC	(13)			
TOTALS				

Notes:

IDNR Lake Michigan Investigations

Stream Fishermen Vehicle Counts

A.M. or P.M.

Stream: SC Date __ /__ /__ Weekend or Weekday Clerk ____

WEATHER:

Average temperature ___ Stormy __.__ hours

Average sky: sunny hazy p. cloudy m. cloudy overcast

Precipitation (% of time that it rained): 0 25 50 75 100

Stream height: flooded high normal low

Stream water clarity: low (muddy) fair high (clear)

Sites		Count 1 __:__ - __:__	Count 2 __:__ - __:__	Count 3 __:__ - __:__
194	(1)			
20	(2)			
OP	(3)			
IG	(4)			
6	(5)			
700	(6)			
149	(7)			
600	(8)			
500	(9)			
130	(10)			
400	(11)			
375	(12)			
JO	(13)			
TOTALS				

Notes:

IDNR **Lake Michigan Investigations** **Stream Creel Interviews**

Stream: LC TC SC
A.M. or P.M.

Date __/__/__
Page __of__

Weekend or Weekday
Clerk _____

Site	Start Time	Interview Time	Complete Trip Y/N	Come By Car Y/N	Number of Anglers	How Many Caught at Least 1 Fish	Species Fished For	Favorite Species in Streams	FISH HARVESTED										Fish On–Not Caught	Most Successful Lure / Bait	NOTES
									Brown Trout	No. Released	Steelhead	No. Released	Chinook Salmon	No. Released	Coho Salmon	No. Released	Other	No. Released			

IDNR **Lake Michigan Investigations** **Fishing Effort Counts**

Site: BH EC HA MC Date:__/__/__ Weekend or Weekday Clerk ___________

WEATHER:

Average temperature (°F)___ Stormy __.__ hours Foggy __.__hours

Average sky: sunny hazy p. cloudy m. cloudy overcast

Precipitation (% of time that it rained): 0 25 50 75 100

Winds mainly out of the: N S E W NE NW SE SW

Wave height: 1 (0-3 ft) 2 (3-5 ft) 3 (over 5 ft)

SHORE COUNTS:

Time of Count											
Number of Anglers											
	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9	SC10	SC11

BOAT COUNTS: COUNT PERIOD: 1 (_:00) 2 (_:20) 3 (_:40)

20 Min. Count Starting at:										
Fishing Boats Returning										
	BC1	BC2	BC3	BC4	BC5	BC6	BC7	BC8	BC9	BC10

IDNR **Lake Michigan Investigations** **Lake Creel Survey** **<u>BOAT</u> interviews**

Site: BH EC HA MC Date___/___/___ Weekend or Weekday

Page ___of___ Clerk _______________

Start Time	Quit Time	Chater Y / N	Number of Anglers	How Many Caught at Least 1 Fish	Species Fished For	Favorite L. Mich. Species to Fish For	FISH HARVESTED							Most Successful Lure / Bait	Depth Fished (feet)	State Waters Fished	Undersized Released Number and Species	Legal Released Number and Species	NOTES
							Coho Salmon	Chinook Salmon	Steelhead	Brown Trout	Lake Trout	Yellow Perch	Other (Number and Species)						

IDNR   Lake Michigan Investigations   Lake Creel Survey   <u>SHORE</u> interviews

Site: BH EC HA MC   Date___/___/___   Weekend or Weekday

Page ___of___   Clerk _______________

Start Time	Interview Time	Complete Trip Y/N	Number of Anglers	How Many Caught at Least 1 Fish	Species Fished For	Favorite L. Mich. Species to Fish For	FISH HARVESTED							Most Successful Lure / Bait	Undersized Released Number and Species	Legal Released Number and Species	NOTES
							Coho Salmon	Chinook Salmon	Steelhead	Brown Trout	Lake Trout	Yellow Perch	Other (Number and Species)				

IDNR LAKE MICHIGAN INVESTIGATIONS BIODATA

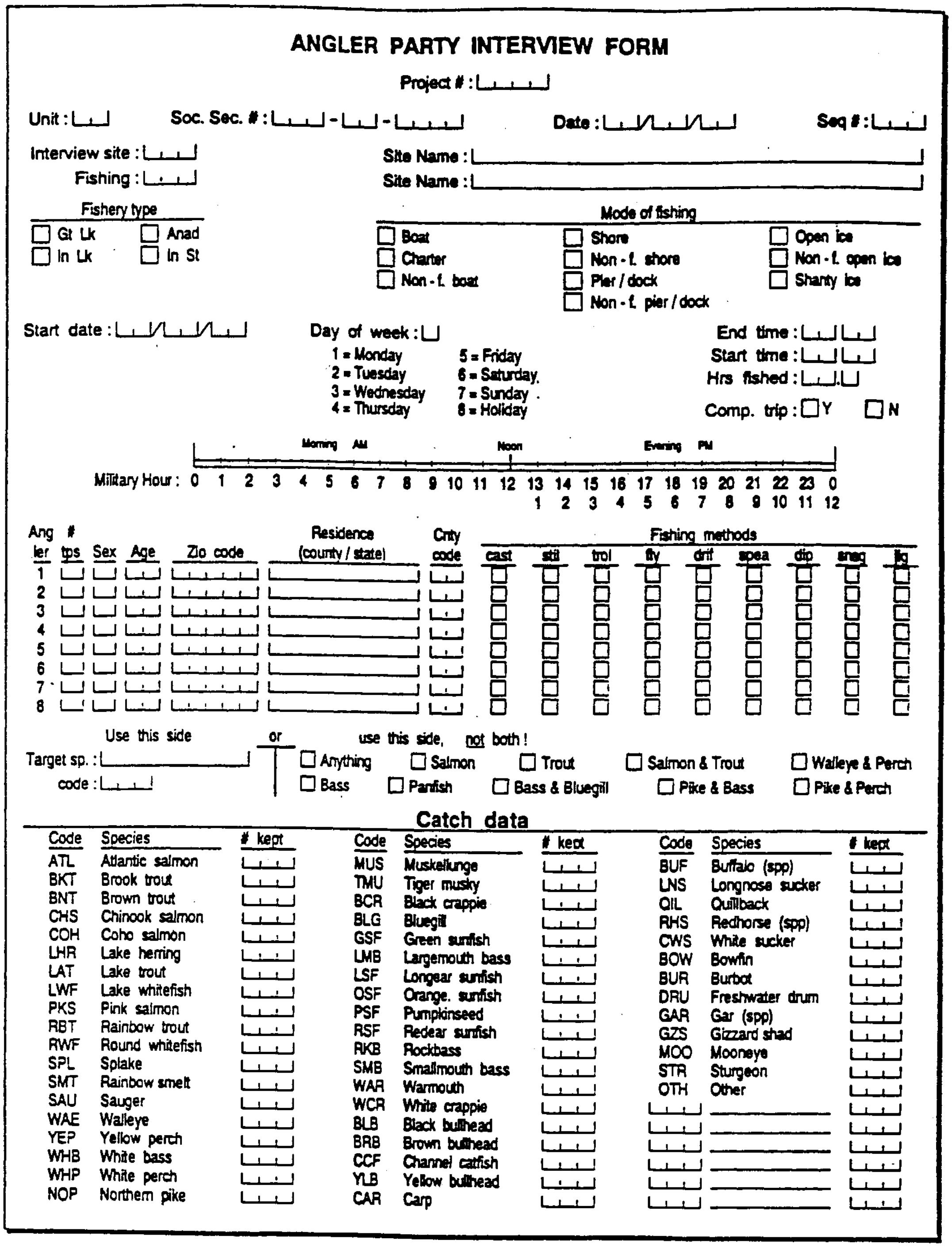
BOAT SHORE STREAM

Site: BH EC HA MC
LC SC TC

Date__/__/__ Weekend or Weekday

AM or PM Page __of__ Clerk ____________

Species	Fins Clipped	Length		Species	Fins Clipped	Length		Species	Fins Clipped	Length		Species	Fins Clipped	Length



ANGLER PARTY INTERVIEW FORM

Project # :

Unit :   Soc. Sec. # : - -   Date : / /   Seq # :

Interview site :   Site Name :

Fishing :   Site Name :

Fishery type

☐ Gt Lk ☐ Anad

☐ In Lk ☐ In St

Mode of fishing

☐ Boat ☐ Shore ☐ Open ice

☐ Charter ☐ Non - f. shore ☐ Non - f. open ice

☐ Non - f. boat ☐ Pier / dock ☐ Shanty ice

☐ Non - f. pier / dock

Start date : / /

Day of week :

1 = Monday 5 = Friday

2 = Tuesday 6 = Saturday

3 = Wednesday 7 = Sunday

4 = Thursday 8 = Holiday

End time :

Start time :

Hrs fished : .

Comp. trip : ☐ Y ☐ N

Morning AM Noon Evening PM

Military Hour : 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0

1 2 3 4 5 6 7 8 9 10 11 12

Ang ler	# tps	Sex	Age	Zip code	Residence (county / state)	Cnty code	cast	stil	trol	fly	drif	spea	dip	snag	jig
							Fishing methods								
1							☐	☐	☐	☐	☐	☐	☐	☐	☐
2							☐	☐	☐	☐	☐	☐	☐	☐	☐
3							☐	☐	☐	☐	☐	☐	☐	☐	☐
4							☐	☐	☐	☐	☐	☐	☐	☐	☐
5							☐	☐	☐	☐	☐	☐	☐	☐	☐
6							☐	☐	☐	☐	☐	☐	☐	☐	☐
7							☐	☐	☐	☐	☐	☐	☐	☐	☐
8							☐	☐	☐	☐	☐	☐	☐	☐	☐

Use this side or use this side, not both !

Target sp. :

code :

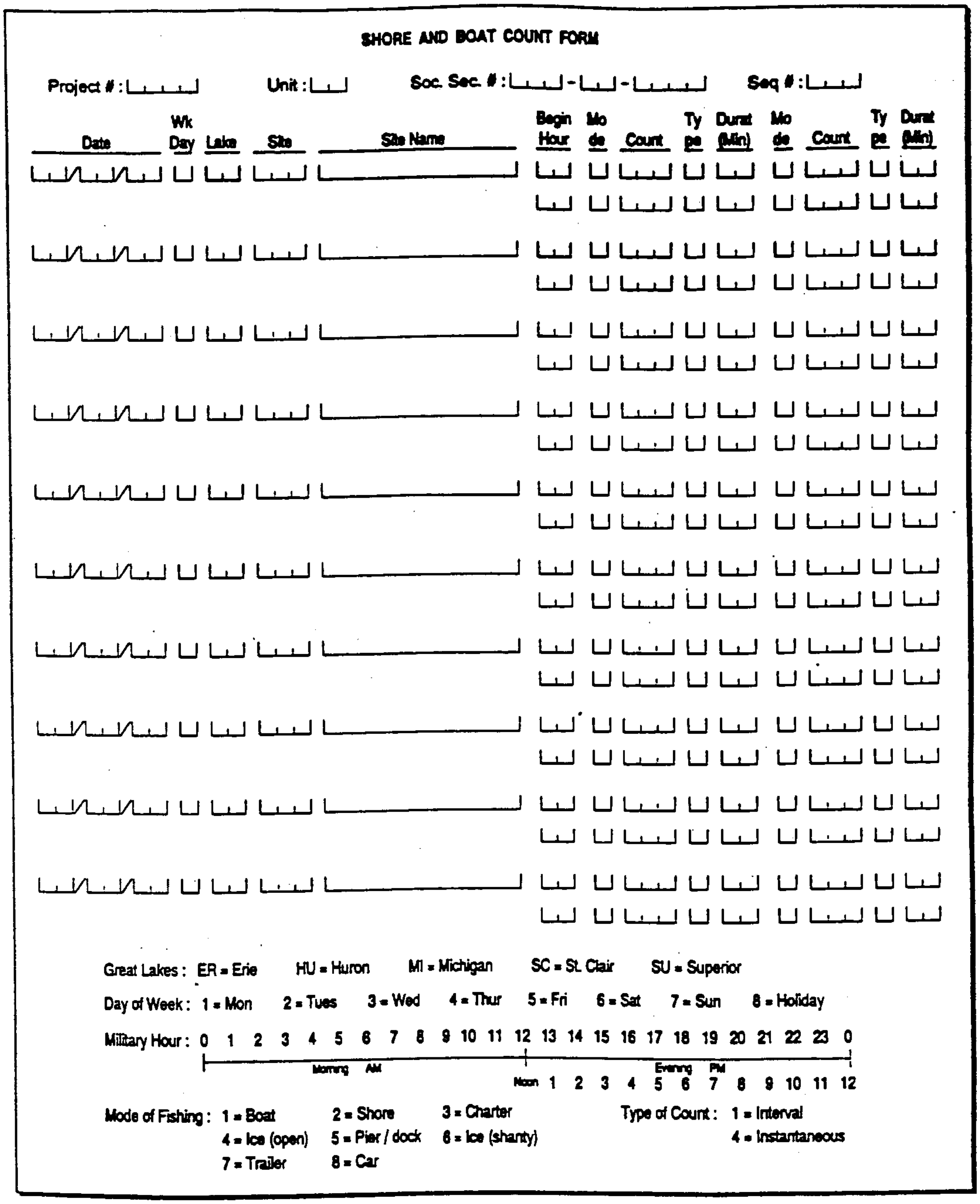
☐ Anything ☐ Salmon ☐ Trout ☐ Salmon & Trout ☐ Walleye & Perch

☐ Bass ☐ Panfish ☐ Bass & Bluegill ☐ Pike & Bass ☐ Pike & Perch

Catch data

Code	Species	# kept	Code	Species	# kept	Code	Species	# kept
ATL	Atlantic salmon		MUS	Muskellunge		BUF	Buffalo (spp)	
BKT	Brook trout		TMU	Tiger musky		LNS	Longnose sucker	
BNT	Brown trout		BCR	Black crappie		QIL	Quillback	
CHS	Chinook salmon		BLG	Bluegill		RHS	Redhorse (spp)	
COH	Coho salmon		GSF	Green sunfish		CWS	White sucker	
LHR	Lake herring		LMB	Largemouth bass		BOW	Bowfin	
LAT	Lake trout		LSF	Longear sunfish		BUR	Burbot	
LWF	Lake whitefish		OSF	Orange. sunfish		DRU	Freshwater drum	
PKS	Pink salmon		PSF	Pumpkinseed		GAR	Gar (spp)	
RBT	Rainbow trout		RSF	Redear sunfish		GZS	Gizzard shad	
RWF	Round whitefish		RKB	Rockbass		MOO	Mooneye	
SPL	Splake		SMB	Smallmouth bass		STR	Sturgeon	
SMT	Rainbow smelt		WAR	Warmouth		OTH	Other	
SAU	Sauger		WCR	White crappie				
WAE	Walleye		BLB	Black bullhead				
YEP	Yellow perch		BRB	Brown bullhead				
WHB	White bass		CCF	Channel catfish				
WHP	White perch		YLB	Yellow bullhead				
NOP	Northern pike		CAR	Carp				

Figure 5.—Angler party interview form.



SHORE AND BOAT COUNT FORM

Project # :

Unit :

Soc. Sec. # :

Seq # :

Date	Wk Day	Lake	Site	Site Name	Begin Hour	Mode	Count	Type	Durat (Min)	Mode	Count	Type	Durat (Min)

Great Lakes : ER = Erie HU = Huron MI = Michigan SC = St. Clair SU = Superior

Day of Week : 1 = Mon 2 = Tues 3 = Wed 4 = Thur 5 = Fri 6 = Sat 7 = Sun 8 = Holiday

Military Hour : 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0

Morning AM

Noon 1 2 3 4 5 6 7 8 9 10 11 12

Evening PM

Mode of Fishing : 1 = Boat 2 = Shore 3 = Charter 4 = Ice (open) 5 = Pier / dock 6 = Ice (shanty) 7 = Trailer 8 = Car

Type of Count : 1 = Interval 4 = Instantaneous

Figure 6.—Shore and boat count form.

Figure 2. Activity count form

DEPARTMENT OF NATURAL RESOURCES
BOX 7921
MADISON, WISCONSIN 53707

GREAT LAKES CREEL SURVEY
FORM 3600-971 REV. 5-91

ACTIVITY COUNT FORM
SHEBOYGAN SURVEY UNIT: MAY 15 - AUGUST 31

Date: __ __ / __ __ / __ __ Clerk: ______________________
month day year

Site Name	County	Site	Count Type	Time (24 H)	Count	Comments
Cleveland Ramp	36	118	2-Trailers*	__ __ : __ __	__ __ __ __	
Sheboygan Ramps	60	122	2-Trailers*	__ __ : __ __	__ __ __ __	
Sheboygan Piers	60	210	1-Anglers	__ __ : __ __	__ __ __ __	
Sheboygan Shore	60	314	1-Anglers	__ __ : __ __	__ __ __ __	
Edgewater Power Plant	60	318	1-Anglers	__ __ : __ __	__ __ __ __	

* At these sites all parties including non-fishing parties must be interviewed.

Added Power Plant in 1994.

Figure 3. Angler interview form

Department of Natural Resources

ANGLER INTERVIEW FORM

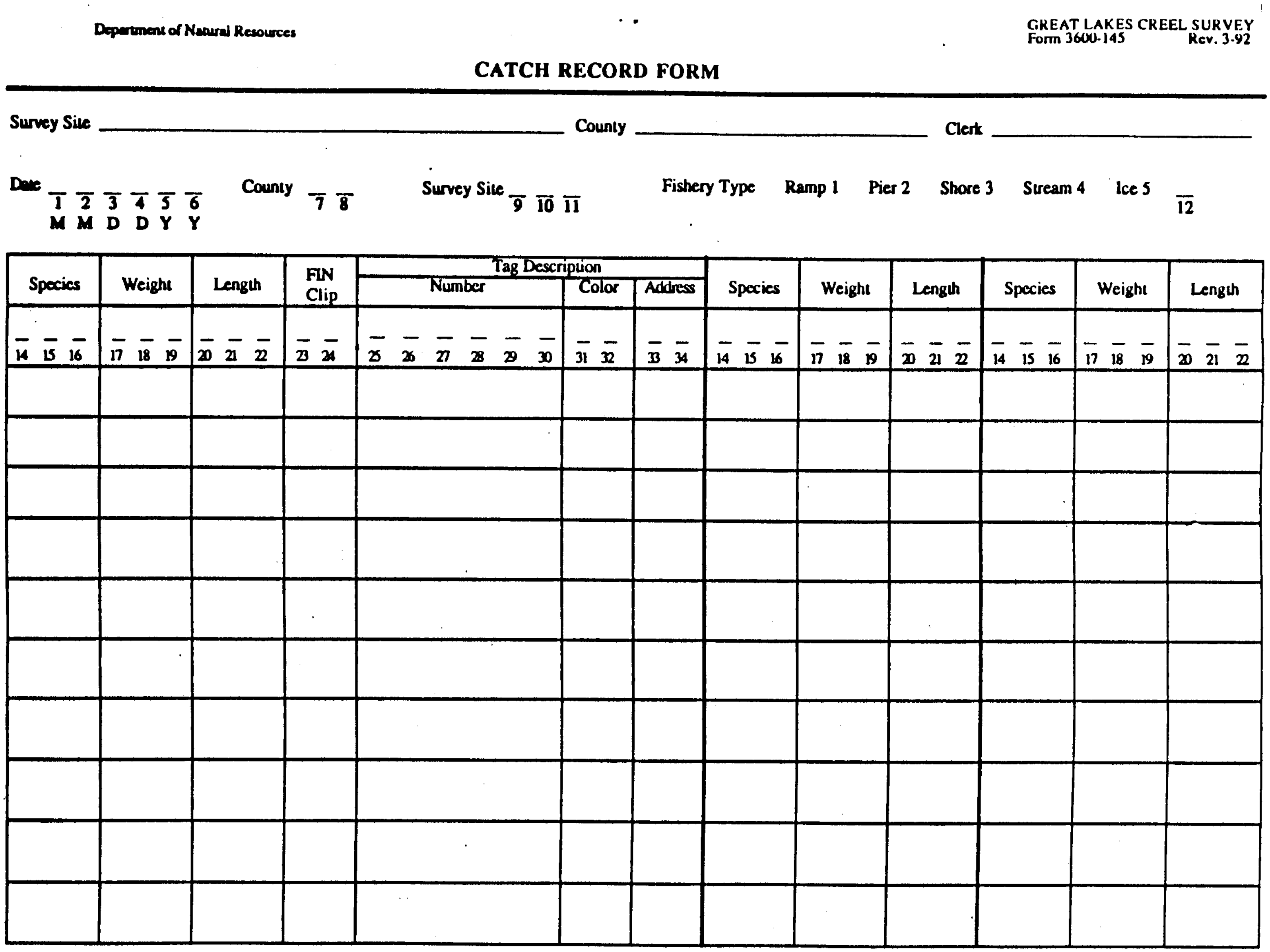
GREAT LAKES CREEL SURVEY
Form 3600-073 Rev. 3-92

Survey Site ________________ County ________________ Clerk ________________

Date _ _ _ _ _ _ (1 2 3 4 5 6; M M D D Y Y) County _ _ (7 8) Survey Site _ _ _ (9 10 11) Fishery Type Ramp 1 Pier 2 Shore 3 Stream 4 Ice 5 _ (12)

	PARTY RECORD						BROWN			RAINBOW			LAKE			COHO			CHINOOK			PERCH		
	Activities	No. Res. Anglers	No. NonR Anglers	Trip Status	Time Interview	Time Started Fishing	% Time	No. Caught	No. Kept	% Time	No. Caught	No. Kept	% Time	No. Caught	No. Kept	% Time	No Caught	No. Kept	% Time	No. Caught	No. Kept	% Time	No. Caught	No. Kept
1.																								
2.																								
3.																								
4.																								
5.																								
6.																								
7.																								

	WALLEYE			OTHER SPECIES				OTHER SPECIES				OTHER SPECIES			
	% Time	No. Caught	No. Kept	Species Code	% Time	No. Caught	No. Kept	Species Code	% Time	No. Caught	No. Kept	Species Code	% Time	No. Caught	No. Kept
1.															
2.															
3.															
4.															
5.															
6.															
7.															



Department of Natural Resources

GREAT LAKES CREEL SURVEY
Form 3600-145 Rev. 3-92

CATCH RECORD FORM

Survey Site ______________________ County ______________________ Clerk ______________________

Date _ _ _ _ _ _ (1 2 3 4 5 6; M M D D Y Y) County _ _ (7 8) Survey Site _ _ _ (9 10 11) Fishery Type Ramp 1 Pier 2 Shore 3 Stream 4 Ice 5 _ (12)

Species	Weight	Length	FIN Clip	Tag Description			Species	Weight	Length	Species	Weight	Length
				Number	Color	Address						
14 15 16	17 18 19	20 21 22	23 24	25 26 27 28 29 30	31 32	33 34	14 15 16	17 18 19	20 21 22	14 15 16	17 18 19	20 21 22

Figure 4. Catch record form