STUDY FINAL REPORT

State: Michigan

Project No.: F-80-R-3

Study No.: 691

Title: Methods for determining safe harvest levels for fish stocks in inland lakes of northern Michigan

Period Covered: October 1, 2000 to September 30, 2002

Study Objective: To review existing methods for calculating safe harvest levels for fish stocks in inland lakes in northern Michigan; to revise these or develop new methods as needed.

Summary: We reviewed existing methods for calculating safe harvest levels in multiple-user fisheries. Techniques used in the treaty-ceded territory of northern Wisconsin appeared most appropriate for northern Michigan. In Wisconsin, safe harvest estimates for walleye *Stizostedion vitreum vitreum* in lakes are calculated from mark-recapture abundance estimates. If no recent mark-recapture estimates are available, estimates of abundance (and then safe harvest) are made from a regression of abundance versus lake size. The regression parameters must be estimated from mark-recapture estimates made in lakes similar to one in question. We lacked sufficient fish abundance estimates in northern Michigan lakes to either test the validity of using the Wisconsin-derived regression parameters or to develop our own regression parameters. Therefore, we decided to design and test field procedures for obtaining the needed abundance estimates for walleye and northern pike *Esox lucius* in large, inland lakes of northern Michigan. We also tagged muskellunge *E. musquinongy* to attempt estimates for them, but expected them to be too rare to in our lakes to calculate abundance estimates. We focused initial efforts on walleye, northern pike, and muskellunge because these species are the primary targets of tribal fishing in the 1842-treaty-ceded territory, and also, they support valuable sport fisheries in most large lakes of Northern Michigan. Methods for calculating safe harvests for other species will be developed in the future if needed. Our basic approach was to net and jaw-tag fish during spring spawning runs, and then to obtain ratios of marked-to-unmarked fish through a year-long creel survey. The Chapman modification of the Peterson method was used to generate abundance estimates. We conducted mark-recapture estimates on Burt, Crooked, Pickerel, and Houghton lakes and Michigamme Reservoir in the spring of 2001. Creel surveys were completed on these 2001 lakes in winter 2000-2001, summer 2001, and winter 2001-2002. We conducted the tagging operations for future abundance estimates on Leelanau, Muskegon, and the Cisco Chain lakes in the spring of 2002. Creel surveys will be completed on these 2002 lakes in summer and winter of 2002-2003. During netting operations, we measured numbers and lengths of all fish captured and collected spines or fin rays from walleye and northern pike for age analysis. The method we used appeared to give good results, so we designed and initiated work on a new, long-term study (725) to get population estimates on more lakes. In addition, angler tag returns allowed us to estimate angler exploitation and fish movement. Aging of fish was not completed during the course of Study 691, but will continue with Study 725. This report describes the netting effort and provides preliminary estimates of abundance, exploitation, and movement of walleye and northern pike as derived from tag returns. Study 646 gives estimated harvests resulting from creel surveys. Future reports for Study 725 will give final results of abundance, exploitation, movement, and age and growth analysis for lakes surveyed in 2001 and 2002. We will continue to conduct abundance estimates on about 4 other lakes per year to test the Wisconsin regression or develop a new one.

Findings: This Final Report covers progress for all jobs for the life of the project.

Job 1. Title: Review existing techniques for calculating safe harvest levels and recommend which should be used in Michigan.–Existing techniques for calculating safe harvest levels in Wisconsin and Minnesota mixed-user fisheries were reviewed. Techniques vary greatly between Wisconsin and Minnesota, largely due to the number and size of lakes subject to tribal harvest in each state.

Wisconsin DNR has developed regression models that predict adult walleye abundance from lake area for both stocked and naturally producing lakes in the 1837 and 1842 treaty-ceded areas (Hansen 1989). Safe harvest is derived from regression population estimates using a safety factor that limits the probability of overharvest to 1 in 40 (Hansen et al. 1991). This type of modeling approach is appropriate for calculating safe harvest over a large suite of lakes of varying sizes and recruitment sources. The treaty-ceded area in Wisconsin encompasses 22,400 m^2 and 2,300 lakes larger than 25 acres (U.S. Department of the Interior 1991).

Minnesota DNR uses a modeling approach based on gill-net catch-per-unit-effort (CPUE) as an index of walleye abundance (Don Pereira, personal communication). Safe annual harvest is set at 24% of the total walleye abundance for a lake. The majority of tribal harvest in Minnesota occurs in Mille Lacs, a large 132,000-acre lake in the 1837 treaty-ceded area. This gill-net based approach is appropriate for large lakes where estimating population size through mark and recapture sampling is impractical, but is likely inappropriate for small lakes where gill nets could harm the fish population.

The 1842 treaty-ceded area in Michigan contains approximately 546 lakes greater than 25 acres, 186 lakes greater than 100 acres, and 17 lakes greater than 1,000 acres. The 1836 treaty-ceded area in Michigan contains approximately 1,385 lakes greater than 25 acres, 451 lakes greater than 100 acres, and 55 lakes greater than 1,000 acres. Given the number of small lakes in the Treaty-ceded areas and the small number of extremely large lakes, the Wisconsin approach would be more appropriate; however, other techniques like hydroacoustic sampling will continue to be explored.

Job 2. Title: Evaluate the usefulness of existing population survey data for making harvest limit calculations.–Existing data was reviewed using Michigan Department of Natural Resource's Fish Collection System software. Detailed fisheries assessments of large inland lakes were found to be lacking, largely because they are labor intensive and expensive. Additionally, many of the existing population estimates are outdated. Current population estimates are needed to develop effective models for predicting gamefish abundance in un-sampled lakes.

Job 3. Title: Develop procedures for calculating safe harvest levels and acquire any needed software. Explain assumptions of techniques and how to interpret results.–In the Wisconsin treaty-ceded territory, safe harvest estimates for walleye in lakes are calculated from mark-recapture abundance estimates. If no recent mark-recapture estimates are available, estimates of abundance (and then safe harvest) are made from a regression of abundance versus lake size. The regression parameters must be estimated from mark-recapture estimates made in lakes similar to the one in question. We lacked sufficient fish abundance estimates for northern Michigan lakes to either test the validity of using the Wisconsin-derived regression parameters or to develop our own regression parameters. Therefore, we decided to design and test field procedures for obtaining the needed abundance estimates for walleye and northern pike in large, inland lakes of northern Michigan. We also tagged muskellunge to attempt estimates for them, but expected them to be too rare to in our lakes to calculate abundance estimates. We focused initial efforts on walleye, northern pike, and muskellunge because these species are the primary targets of tribal fishing in the 1842-treaty-ceded territory, and also because they support valuable sport fisheries in most large lakes of Northern Michigan. Methods for calculating safe harvests for other species will be developed in the future if needed. Our basic approach was to net and jaw-tag fish during spring spawning runs, and then to obtain ratios of marked-to-unmarked fish through a year-long creel survey. The Chapman modification of the Peterson method was used to generate abundance estimates. Creel clerks inspected harvested fish for tags, but voluntary returns were also encouraged. Fifty percent of the tags were redeemable for a ten dollar reward. This report describes the netting effort and provides preliminary estimates of abundance, exploitation, and movement of walleye and northern pike as derived from tag returns. Study 646 gives estimated harvests resulting from creel surveys. Future reports for Study 725 will give final results of abundance, exploitation, movement, and age and growth analysis.

In the spring of 2001, legal-sized walleye, northern pike, and muskellunge were jaw tagged in Burt, Crooked, Pickerel, and Houghton lakes and Michigamme Reservoir (Table 1). Creel surveys were completed on these 2001 lakes in winter 2000-2001, summer 2001, and winter 2001-2002 (Study 646). We conducted the tagging operations for future abundance estimates on Leelanau, Muskegon, and the Cisco Chain lakes in the spring of 2002 (Table 1). Smallmouth bass *Micropterus dolomieu* were also tagged on Lake Leelanau to attempt a mark-recapture estimate for them. Creel surveys will be completed on these 2002 lakes in summer 2002 and winter 2002-2003. Due to the large size of these lakes, substantial field effort was required to mark sufficient numbers of fish. We used field staffs of up to 15 persons per week per lake working up to 40 trap and fyke nets and 3 electrofishing boats over 3 weeks. We prepared field methods in written form (see Addendum) and distributed them to staff in advance during work planning sessions. Local Technician Supervisors managed the day-to-day field operations at each lake, and we provided statewide oversight.

Abundance estimates–We used the Wisconsin regression model for lakes with natural reproduction of walleye to predict abundance from lake area (Hansen 1989), and we set tagging goals at 10% of the predicted population size. We did not reach our tagging goals in any of the lakes, though we likely marked enough fish for accurate estimates of population size. We will show later that the Wisconsin model tended to overestimate walleye abundance in our lakes. In the future we will determine marking goals based on charts provided by Robson and Regier (1964) that give combinations of number marked (M) and number checked for marks (C) that correspond with an educated guess of abundance (prediction from Wisconsin model). Combinations of M and C will be chosen based on realistic marking capabilities (time and budget) and expected creel samples from historic data.

The approach we used allowed us to compute two separate population estimates, one derived from marked-unmarked ratios from spring netting operation (multiple census) and one derived from marked-unmarked rations from creel survey (bi-census). Initially, Schumacher/Eschmeyer and Chapman/Schnabel multiple census population estimates were derived from recaptures during the tagging operation. These preliminary estimates gave us an idea of abundance in each lake, but they were largely intended for the purpose of comparison with the bi-census population estimate from the creel survey. We assumed that the estimate from the creel survey would be the better of the two if we could obtain sufficient recaptures, because it would allow sufficient time for the marked fish to fully mix with unmarked fish. Netted fish were targeted during spawning congregations, and the spawning congregations we netted might not have been representative of whole lake populations.

The minimum number of recaptures necessary for an unbiased estimate was set *a priori* at four (Ricker 1975). Generally, the multiple census estimates coincided with the bi-census estimates, though when the total number of marked fish was less than 100 the number of recaptures was also small; thus, the estimate was potentially biased. This was only a potential problem for northern pike and muskellunge in a few lakes where we did not tag more than 100 fish. Additionally, the Schumacher/Eschmeyer formula is heavily weighted towards the ratio of marked to unmarked fish collected on the final day of sampling. Consequently, when few fish were collected on the final day the estimate was likely biased. This decrease in catch occurs occasionally as the end of the spawning period approaches and fish leave the spawning grounds. The Chapman modification of the Schnabel method provided estimates close to those derived from the Schumacher/Eschmeyer method; therefore either formula could be used. Both symmetrical and asymmetrical 95% confidence intervals were obtained for each estimate. The best estimator of variance for single estimates utilizes reciprocals of N (Ricker 1975) and provides asymmetrical intervals. However, if variance estimates were to be combined (i.e. when summing two size groups) a separate variance equation was used which provided symmetrical confidence intervals.

Year-long creel surveys were conducted on each of the lakes to obtain a ratio of marked to unmarked fish. The Chapman modification of the Petersen method was used to generate population estimates. The general assumption of this bi-census method is that the proportion of marked fish in the second sample estimates the proportion of marked fish in the total population. If our two methods for obtaining samples select for different sizes the estimate could be biased. Our first (netting) and second (angling) methods of sampling probably did have different size selectivity over full ranges of sizes in the populations, but we assumed that for the larger sizes of fish we marked (15+ in for walleye; 24+ in for northern pike, 50+ in for muskellunge, 14+ in for smallmouth bass) differences in selectivity would be negligible. Other assumptions for the Petersen method for abundance estimation are as follows: identifying marks are not lost (i.e. fin regeneration or tag shedding); marking does not induce mortality; marked fish are equally vulnerable to capture; thorough mixing occurs between marked and unmarked fish before the recapture period; no fish immigrate into, or are recruited into the size class of interest; all marks are recognized (we assume 100% recognition from creel clerks).

The number of fish marked and checked for marks affects the precision and accuracy of population estimates. We used the charts provided by Robson and Regier (1964) to determine the number of fish that needed to be examined for marks based on the Wisconsin model—predicted abundance and the number of fish that we actually marked (Table 2). We used the level of accuracy which they recommend for management studies, or combinations of M and C that are sufficient to generate estimates expected to differ from the true abundance by no more than 25% at the 95% confidence level. The intent of this exercise was to determine if the Wisconsin model could aid in predicting sample sizes, and to ensure that the numbers of fish observed in the creel samples were large enough based on the number marked. None of the creel samples of walleye were large enough to meet the predetermined confidence levels (Table 2). To help solve this problem, we will consider other ways to supplement the number of recaptures from the creel survey. One possibility would be to collect additional recaptures while conducting walleye Serns Indices during September. The Serns Indices would also be helpful in managing the walleye fisheries.

Tag returns in each lake were sufficient to obtain viable population estimates, with the exception of northern pike in Crooked and Pickerel lakes (Table 3). Few legal sized northern pike were tagged on these lakes. Generally the population estimates from the creel survey did not correspond well with the multiple census population estimates (Table3). However, the creel population estimates have not yet been corrected for fish recruited to legal size during the survey; thus, they are likely overestimates of the true population. The estimates from the Wisconsin model were generally higher than the creel estimates, but more closely resembled those estimates from the creel than from the tagging operation. The Wisconsin model may not be appropriate for Michigan lakes, or perhaps there is less natural reproduction going on in some lakes than believed. Another plausible cause for the discrepancy between model estimates and field estimates would occur if a population was being highly exploited, though most of our estimates of exploitation were relatively low at less than 20% (Table 3). It appears that the multiple census population estimates derived during the tagging operation underestimated population sizes. A probable cause is that all fish in each lake were not present in the spawning congregations we sampled.

Age and growth–We will ultimately adjust the proportion of tagged fish observed in the creel for fish that grew into, or were recruited into legal size over the course of the creel survey. This adjustment will largely be based on historic growth rates and observed length at age for each lake. Making the adjustment will somewhat reduce the bi-census population estimates given in Table 3, because it will properly increase the number of unmarked fish of legal size.

All pike and walleye were aged using dorsal spine or fin ray sections. We collected up to 50 fish per inch group and generally aged 15 fish per sex per inch group. Aging was completed for all lakes by a first reader, and aging was continued with a second reader. A final age will be decided by first comparing the assigned ages from reader 1 and 2; agreement will be justification for a final age. If reader 1 and 2 disagree on an age, then a third reader will age the fish. Thus, a third reader is only incorporated for a portion of the samples. If reader 3 agrees with either reader 1 or 2, that will be justification for a final age. If all three readers disagree on an age the fish will be discarded from analysis. If several samples are discarded from a single inch group the decision will be made whether more fish should be added to the analysis. After completing the extent of this aging analysis for Houghton Lake walleye, we found that few fish were discarded due to poor agreement. For Houghton Lake walleye, there was 52.9% agreement between reader 1 and 2. For fish that were aged by a third reader, agreement was with reader 1 50.2% of the time and with reader 2 49.8% of the time. Only 4.4% of samples were discarded due to poor agreement; thus, at least two readers agreed 95.6% of the time. Similar analysis of reader agreement will be completed for each lake to identify any inconsistencies among readers.

After a final age is identified for all samples growth will be assessed with mean length at age from the time of capture. Annulus formation is likely incomplete at the time of capture; thus, back-calculation will be unnecessary. Back-calculation tends to underestimate length at age, and the analysis combines lengths at age from different age fish with time-varying growth rates. If standard sampling is continued and lakes are sampled at the same time of year then mean length at capture will be sufficient to assess growth. Growth comparisons among lakes, or with historic data may be compromised if different methodology was used in the past, but the key objectives of this study were to obtain incremental growth estimates for adjusting unmarked fish in the creel, and to determine age structure. Age structure will be determined by assigning ages to fish based on an age-length key. Final population estimates will then be apportioned by this age structure. During fish surveys, we also collected biological and relative abundance data. Length-frequency histograms for walleye and northern pike are displayed in Figure 1 for 2001 lakes and Figure 2 for 2002 lakes.

Exploitation and movement–Annual exploitation (%) was calculated for lakes sampled in 2001 from the proportion of issued reward tags that were voluntarily returned (Table 3). All estimates are low to moderate for walleye and northern pike sport fisheries with the exception of Michigamme Reservoir, which had a relatively high walleye exploitation of 29%. However, even 29% exploitation is probably within safe bounds, because the fishery is also protected by a 15-in-minimum size limit. Annual exploitation will also be calculated from the creel survey results by dividing harvest by the abundance estimate. Winter creel results were not completed at the time of this report, so these calculations were not made. When results are completed, they will be reported under the new study 725.

Movement of walleye and pike was examined based on voluntary tag returns. Significant movement of walleye only occurred in the Burt - Crooked - Mullet system, though there was some movement out of Michigamme Reservoir (Table 4). Approximately 7.1% of the walleye tagged in Burt Lake moved into Mullet Lake after tagging. No walleyes tagged in Mullet Lake moved into Burt Lake after tagging. Hence, if spawning populations are of similar size there may be net movement of walleye from Burt into Mullet. However, it is reasonable to assume that the error in our crude estimate of movement is large enough so that we can consider no net movement and disregard this caveat when making a population estimate. Approximately 98% of the walleye tagged in Crooked Lake remained there after tagging; only 2% moved into Pickerel Lake. On the contrary, 48% of the walleye tagged in Pickerel were caught there, while 52% moved into Crooked Lake. The extent of walleye movement out of Pickerel Lake suggests that it is perhaps only used as a spawning area for Crooked Lake resident walleye. This is supported by the creel data from Pickerel Lake which showed little harvest. The extent of walleye movement out of Michigamme Reservoir was small with one fish being caught in a connected lake, and one caught in the Michigamme River (Table 4). There was no observed movement of walleye or northern pike out of other lakes. The percent movement from tag returns will be converted to an estimate of the number of fish based on population estimates.

We did not need to acquire any new software, as existing software was adequate. A database was designed in Microsoft ACCESS for data collected during the tagging operation as well as for tag return data. ArcView GIS by ESRI was used to map net locations.

Findings from Study 691 resulted in the initiation of Study 725, Fisheries assessments in large, inland lakes of Michigan. Study 725 will continue annual population estimates on large inland lakes for the purpose of developing a model to predict gamefish abundance from morphometric or physicochemical lake characteristics. Lakes were selected for tagging in 2003 and field protocols will be similar to those used in 2001 and 2002.

Job 4. Title: Write final report.–This Final report was completed September 30, 2002.

Job 5. Title: Publish report through the Fisheries Division's editing and finishing process for Research and Technical reports.–We will not publish a research report for Study 691; the study will end one year early.

Literature Cited:

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Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Robson, D. S., and H. A. Regier. 1964. Sample size in Petersen mark-recapture experiments. Transactions of the American Fisheries Society 93:215-226.

U.S. Department of the Interior. 1991. Casting light upon the waters: a joint fishery assessment of the Wisconsin ceded territory. Bureau of Indian Affairs, Minneapolis, MN.

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Date: September 30, 2002

Table 1–Summary of sampling effort and numbers of target species captured in Michigan large lakes in spring 2001. Net lifts includes both trap and fyke nets combined.

Year county lake	Size (acres)	Dates sampled	Net lifts	Electrofishing runs	Species	Total captured[2]
2001						
Cheboygan						
Burt	17,387	04/19-05/09	352	6	walleye	2,703
					northern pike	174
Emmet						
Crooked	2,351	04/17-04/25	54	1	walleye	413
					northern pike	136
Pickerel	1,082	04/17-04/26	58	1	walleye	538
					northern pike	140
Roscommon						
Houghton	20,067	04/9-05/01	524	14	walleye	4,258
					northern pike	1,080
Iron						
Michigamme	7,000	04/19-05/04	209	10	walleye	2,024
					northern pike	1,503
2002						
Leelanau						
Leelanau	8,607	04/08-04/27	271	8	walleye	3,456
					northern pike	901
					smallmouth bass	245
Muskegon						
Muskegon	4,232	03/04-03/30	14	35	walleye	4,631
					northern pike	13
Gogebic, MI & Vilas, WI						
Cisco Chain[1]	3,414	04/15-05/03	445	16	walleye	9,537
					northern pike	3,072
					muskellunge	54

[1] Includes 11 interconnected lakes.
[2] Includes both legal- and sublegal-size fish. Legal-sizes were: 15+ in for walleye, 24+ in for northern pike, 50+ in for muskellunge, and 14+ in for smallmouth bass.

Table 2.–Predicted number of walleye to be examined for marks (*C*) based on the Wisconsin model abundance estimate and the number of fish actually marked (*M*) in Michigan large lakes in 2001. Predicted number (*C*) was taken from charts provided by Robson and Regier (1964) for predicting sample size sufficient to generate Petersen population estimates expected to differ from the true abundance by no more than 25% at the 95% confidence level.

Lake	Wisconsin model abundance estimate	*M*	Predicted *C*	Actual *C*
Burt	52,012	1,877	1,750	341
Crooked	7,816	277	1,500	161
Pickerel	3,746	224	900	23
Houghton	59,576	3,072	1,000	367
Michigamme	15,641	1,062	900	406

Table 3.–Summary of number tagged, exploitation (u) estimates, and population estimates for legal-sized walleye (WAE) and northern pike (NOP) sampled in Michigan large lakes in 2001. Annual u was estimated from reward tag returns. Confidence intervals for the population estimates, ±2 SE, are shown in parentheses.

Lake	Species	Number tagged	Total tag returns	Annual u (%)	Population estimates: Multiple census	Population estimates: Bi-census (creel)[3]	Population estimates: Wisconsin model[4]
Burt	walleye	1,877	155	8.7	13,622 (11,276-17,200)	27,925 (18,696-41,473)	52,012 (16,820-160,830)
	northern pike	64	5	7.4	332 (166-53,586)[1]	910 (178-1,228)	No estimate
Crooked	walleye	277	46	16.6	5,078 (2,936-18,796)[1,2]	5,004 (2,674-9,016)	7,816 (2,596-23,535)
	northern pike	7	0	No estimate	No estimate[1,2]	No estimate	No estimate
Pickerel	walleye	224	25	13.2	1,123 (802-1,871)[2]	2,688 (784-5,466)	3,746 (1,250-11,227)
	northern pike	4	0	No estimate	No estimate[1,2]	No estimate	No estimate
Houghton	walleye	3,072	281	10.3	38,656 (31,806-49,265)	66,889 (42,072-105,172)	59,576 (19,215-184,715)
	northern pike	288	40	19.0	1,575 (975-4,094)	20,952 (8,503-42,254)	No estimate
Michigamme	walleye	1,062	271	29.1	2,371 (1,778-3,559)	14,435 (10,145-20,472)	15,641 (5,156-47,443)
	northern pike	94	11	12.2	234 (164-413)[1]	1,013 (359-2,199)	No estimate

[1] Less than 100 fish marked.
[2] Less than 10 recaptures.
[3] Population estimates from creel have not been adjusted for unmarked fish that grew into legal size during the creel survey.
[4] Wisconsin model for predicting walleye abundance from surface area in lakes with natural reproduction.

Table 4.–Matrix of walleye movements based on voluntary angler tag returns from Michigan large lakes in 2001. Columns for each row (lake where tagged) show number of returns from each waterbody. Percent of total tag returns for each lake are in parentheses.

	Lake where tagged			
Location where harvested	Burt	Crooked	Pickerel	Michigamme Reservoir
Burt Lake	140 (90.3)	0	0	
Crooked Lake	4 (2.6)	45 (97.8)	13 (52.0)	
Pickerel Lake	0	1 (2.2)	12 (48.0)	
Mullet Lake	11 (7.1)	0	0	
Michigamme Reservoir				269 (99.3)
Michigamme River				1 (0.35)
Light Lake				1 (0.35)

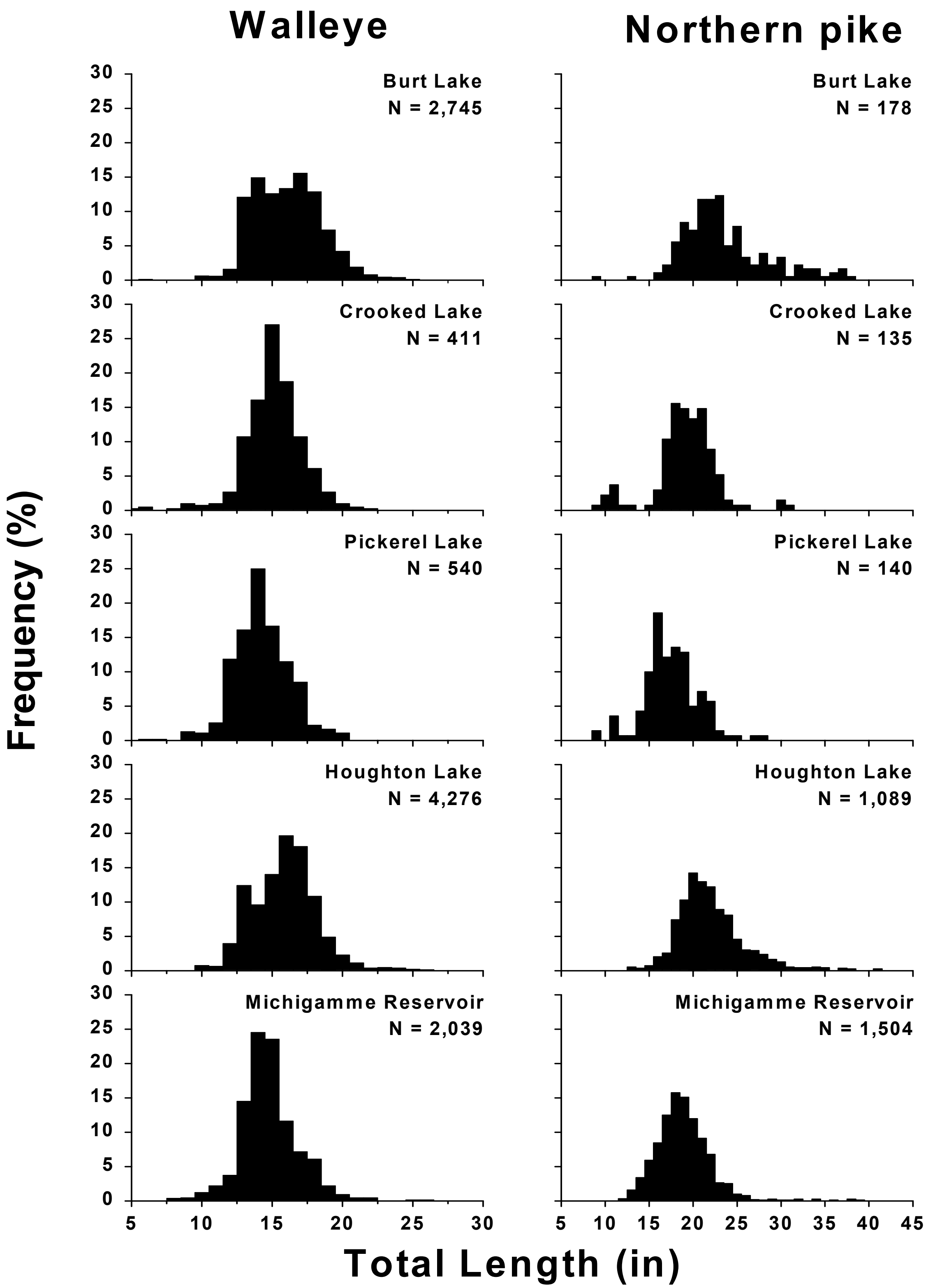


Figure 1.–Length-frequency histograms for walleye and northern pike collected with trap nets, fyke nets, and electrofishing gear in Michigan large lakes in the spring of 2001.

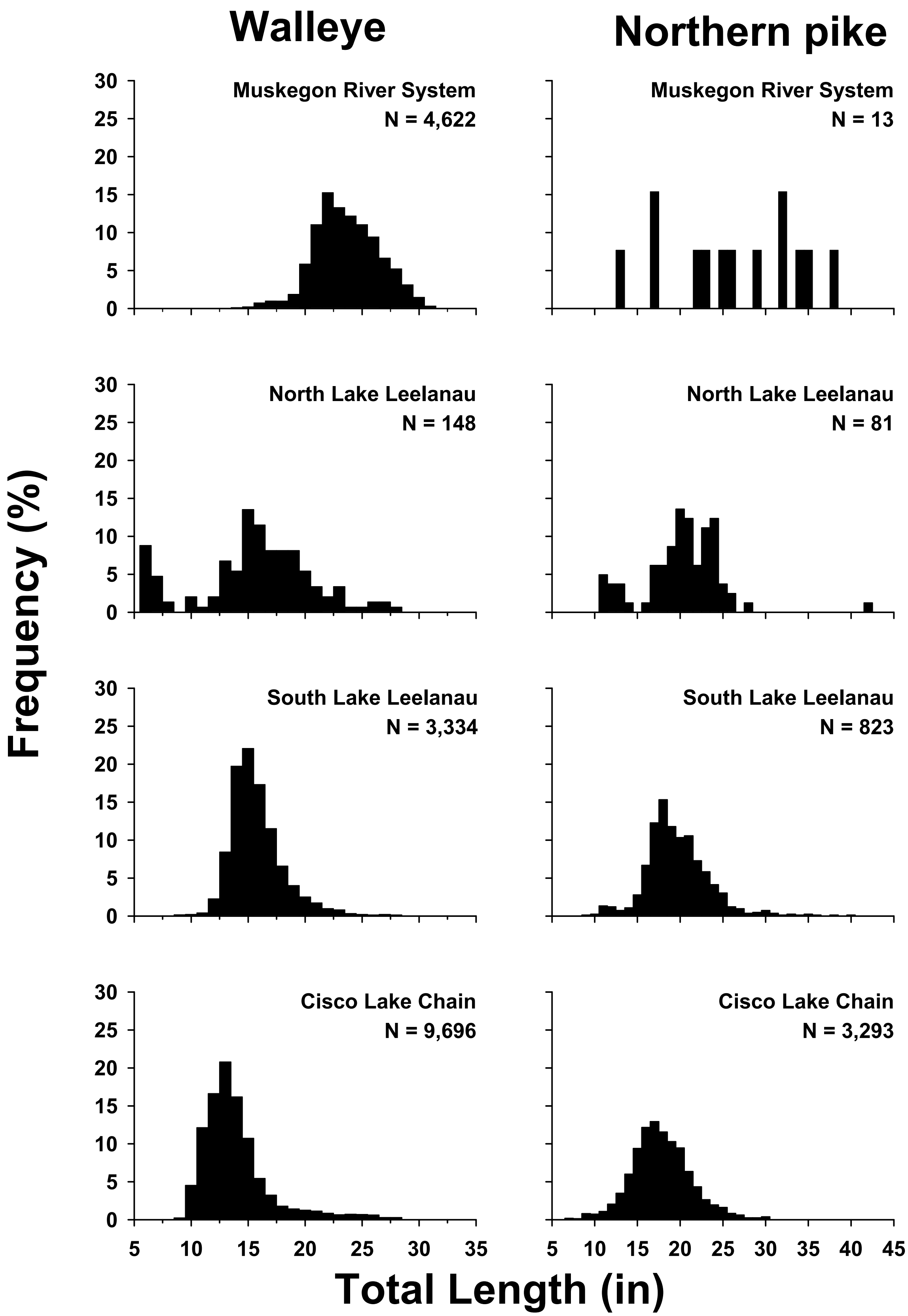


Figure 2.–Length-frequency histograms for walleye and northern pike collected with trap nets, fyke nets, and electrofishing gear in Michigan large lakes in the spring of 2002.

Addendum—Study 691 Field Protocols for Inland Walleye and Pike Tagging 2001

We will be tagging legal sized walleye (15” and larger), northern pike (24” and larger), and muskie (42” and larger) on the following lakes this spring: Houghton, Burt, Crooked, Pickerel, and Michigamme Reservoir. Creel surveys are being conducted on each of these lakes, and the creel clerks will provide tag recapture information so that we can generate population estimates for walleye and pike (muskie if possible). Muskie are being tagged at the request of the managers. We may not encounter and tag enough muskies to get a population estimate, but we will hopefully gain some valuable information on this species.

Marking Goals

We used the regression models developed by WI DNR to estimate the number of adult walleye present in each of our 5 lakes. The WI models predict adult walleye abundance from lake area and yield the following estimates for our target lakes:

Houghton Lake—59,576 adult walleye
Burt Lake—52,012 adult walleye
Crooked Lake—2,794 adult walleye
Pickerel Lake—3,746 adult walleye
Michigamme Reservoir—21,961 adult walleye

We will attempt to tag 10% of the adult population in each of our target lakes. Tagging 10% of the populations will yield an estimate with good precision while still marking a relatively small percentage of the population. Our tagging goals for each lake are as follows:

Houghton Lake—5,958 adult walleye
Burt Lake—5,201 adult walleye
Crooked Lake—279 adult walleye
Pickerel Lake—375 adult walleye
Michigamme Reservoir—2,196 adult walleye

I realize that we might not meet all of the above goals in each lake; however, the closer we get to each goal the better the population estimates will be.

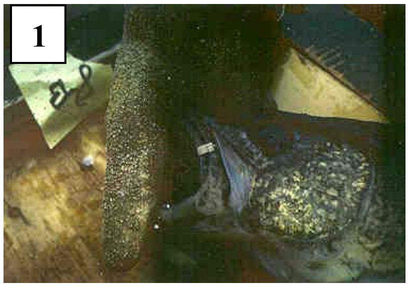
I do not have any idea how many pike or muskie we will encounter in our target lakes. There is no existing model we can use to predict pike and muskie abundance in MI lakes. I expect that in most of our target lakes we will see fewer pike than walleye and very few muskie. So, we will tag all pike and muskie we encounter up to the walleye targets.

Tagging Guidelines

All fish in the 5 lakes will be tagged in the same spot—the upper jaw, as far back on the jaw as possible (see pictures 1 and 2 below). Tags should be wrapped around both the maxilla and pre-maxilla. This may not be possible on some of the larger fish. Tag ends should be butted together tightly so that the tag forms a circle. This allows the tag to move without harming the tagged area of the fish, allows for growth, and makes the tag number easy to read on recaps or angler harvested fish. Tag ends can be overlapped to allow for a snug tag fit. If tags are overlapped, make sure that the tag number is on the outside.

We will be using two different sizes of jaw tags—size 10 and size 12. We will use size 10 tags on 15.0-19.9” walleye. All walleye ≥ 20”, all pike, and all muskie will be tagged with a size 12 tag. If a crew runs out of size 10 tags, size 12’s can be used on smaller walleye. This should be avoided whenever possible, however.

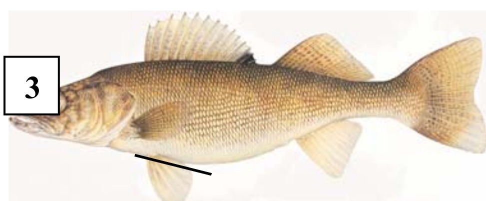
Remember, only legal sized fish are to be tagged. Sub-legal fish will be measured, spine sampled, checked for lymphocystis, sexed, and indexed for maturity but will not be tagged.


1


2

Tag Description
We will be using 3 different tags: 1) size 10 reward tags, 2) size 12 reward tags, and 3) size 12 non-reward tags. We will use reward and non-reward tags in a 50:50 ratio. Each lake will be issued reward and non-reward tags, and it is the responsibility of the crews to ensure that we get as close to the 50:50 reward to non-reward ratio as possible. All reward tags are valued at $10. The reward is offered to stimulate tag returns.

Tag Retention
We will assess tag retention by fin clipping each tagged fish. We need to determine this value in order to adjust our population estimates for any tag shedding that might occur. On all species we will clip the left pelvic fin (left ventral fin for those folks from the Great Lakes). See pictures 3 and 4 below. We will clip off the entire fin as close to the body as possible, without cutting into the base of the fin.


3

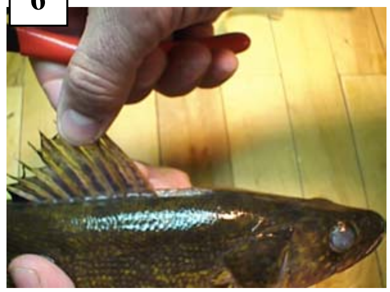
4


Age and Growth Sampling
We will be taking dorsal spine sections off walleye, northern pike, and muskie to index growth and establish length-age keys for all 5 lakes. We will take spine samples from all size ranges of walleye, pike, and muskie from our target lakes.

Protocol for taking spine samples:
1) Use a side cutters to remove the first 3-4 dorsal fin spines, cutting as close to the fish's body as possible (see pictures 5 and 6 below).
2) Lay the fin ray section in a scale envelope as flat and as straight as possible. This is extremely important. If the rays are not laid flat they are difficult to section later and could be unreadable (see picture 7 below).
3) As soon as possible after the completion of field work, lay the "spine" envelopes flat to dry. Once dried, the "spine" envelopes can be stored just like scale envelopes.

5

6



7

A sub-sampling regime was determined for walleye and pike for each lake based on an analysis of historic age data from each lake. The sub-sampling rates for each species in each lake are given below. These sub-sampling rates are goals, and I realize that we might not meet each goal for each species in each lake.

Houghton Lake (4 crews)
Walleye—40 males and 40 females per inch group (10 per sex per inch group per crew)
Northern Pike—32 males and 32 females per inch group (8 per sex per inch group per crew)

Burt Lake (2 crews)
Walleye—20 males and 20 females per inch group (10 per sex per inch group per crew)
Northern Pike—20 males and 20 females per inch group (10 per sex per inch group per crew)

Crooked Lake (1 crew)
Walleye—15 males and 15 females per inch group

Northern Pike—16 males and 16 females per inch group

Pickerel Lake (1 crew)
Walleye—15 males and 15 females per inch group
Northern Pike—16 males and 16 females per inch group

Michigamme Reservoir (2 or 3 crews)
Walleye—75 males and 75 females per inch group (if 3 crews)
50 males and 50 females per inch group (if 2 crews)
Northern Pike—30 males and 30 females per inch group

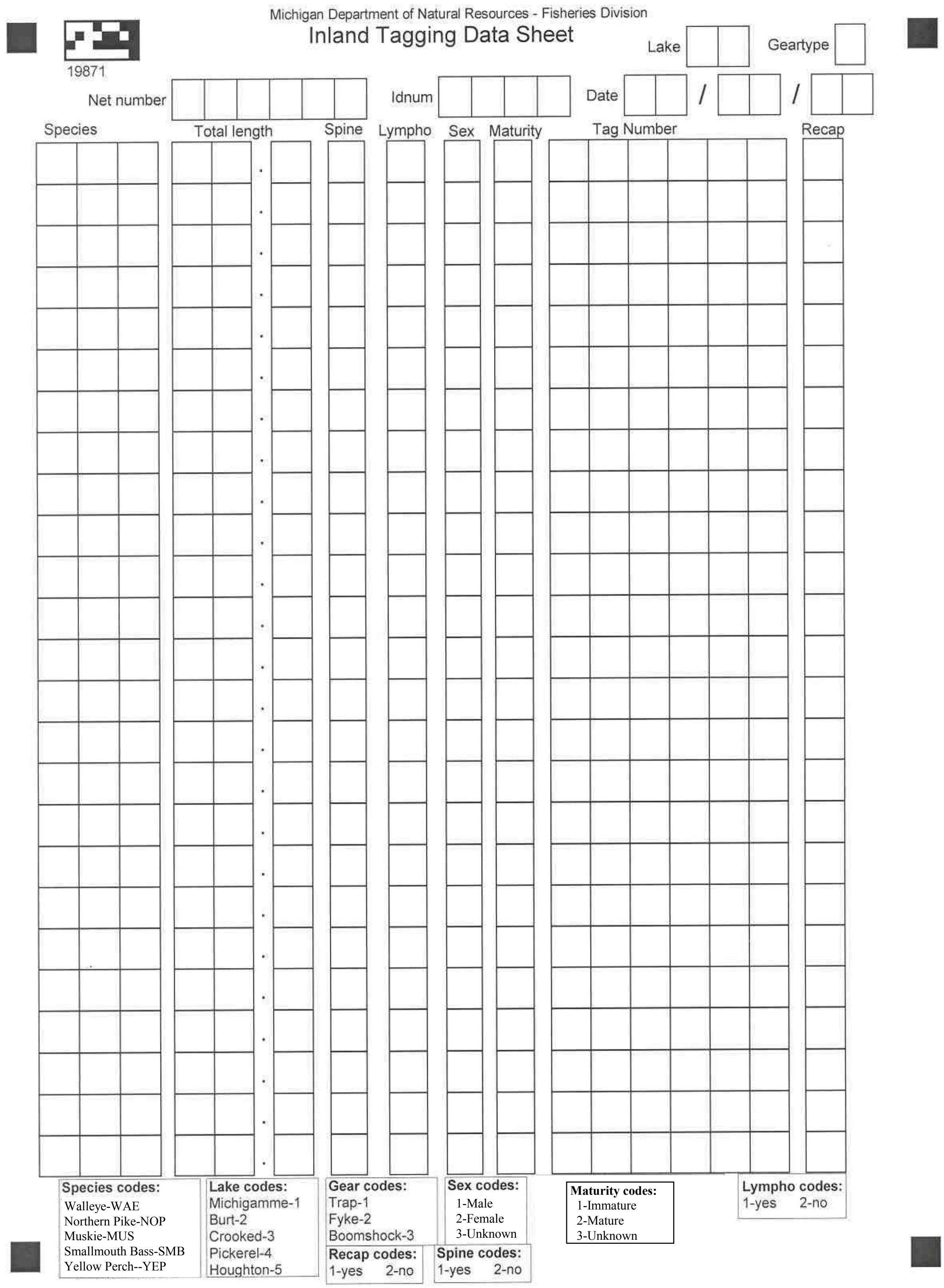
We will take spine samples from all muskie we catch. I don't expect to see enough muskie for this to be a time problem.

Data Sheets

I (Woldt) will provide data sheets to the crews before the beginning of the survey. All data sheets will be on Rite-in-the-Rain© paper. Data will be recorded on data sheets designed in Teleform software. This software allows for rapid data entry. The data sheet is attached below.

A separate data sheet must be used for each net lift or for each day of shocking.

BLANK DATA SHEET


Michigan Department of Natural Resources - Fisheries Division

Inland Tagging Data Sheet

19871

Lake | Geartype

Net number | Idnum | Date / /

Species | Total length | Spine | Lympho | Sex | Maturity | Tag Number | Recap

Species codes:
Walleye-WAE
Northern Pike-NOP
Muskie-MUS
Smallmouth Bass-SMB
Yellow Perch--YEP

Lake codes:
Michigamme-1
Burt-2
Crooked-3
Pickerel-4
Houghton-5

Gear codes:
Trap-1
Fyke-2
Boomshock-3

Recap codes:
1-yes 2-no

Sex codes:
1-Male
2-Female
3-Unknown

Spine codes:
1-yes 2-no

Maturity codes:
1-Immature
2-Mature
3-Unknown

Lympho codes:
1-yes 2-no

EXAMPLE

Michigan Department of Natural Resources - Fisheries Division

Inland Tagging Data Sheet

19871

Lake: 5 Geartype: 1

Net number: GRY 01 Idnum: Date: 04 / 10 / 01

	Species	Total length	Spine	Lympho	Sex	Maturity	Tag Number	Recap
Target	WAE	17.1	1	2	1	2	200000	2
	WAE	15.2	1	2	2	2	200001	2
	NOP	25.6	1	2	1	2	200002	2
Target sub-legal	WAE	14.1	1	1	1	1		
	WAE	13.5	1	2	3	1		
	NOP	19.2	1	2	1	1		
Recap	WAE	.					200220	1
Non-target	YEP	10.5						
	YEP	12.0						
Target legal	WAE	18.3	1	1	1	2	200003	2
	WAE	19.1	1	2	2	2	200004	2
Recap	NOP	.					200119	1
Target legal	MUS	45.3	1	2	1	2	200005	2
	NOP	30.1	1	2	2	2	200006	2
	WAE	17.9	1	2	1	2	200007	2
		.						

As shown in the example above, you will encounter 4 types of fish: 1) target legal, 2) target sub-legal, 3) recaps, and 4) non-target. Not all information on the data sheet needs to be filled out for all types of fish. All fields must be filled out for legal sized target fish (walleye, pike, and muskie). Sub-legal target fish require only species, length, spine, lympho, sex, and maturity fields to be filled out. Recaptured tagged fish require only species, tag number, and recapture fields to be filled out. Non-target fish require only species and length.

Non-target species can be recorded on a separate data sheet, but you must use the form provided. Separating target and non-target like this makes it easier to keep track of the number of tagged fish. Data sheets will have room for 25 fish on the front side and 25 fish on the back side. I will leave this up to the discretion of the data recorder. Remember, if you do this the non-target sheet must have the lake, gear type, net number, and date fields completely filled out so that the target and non-target catch in each net lift can be pooled for data analysis.

The net number field will be filled with the net number from the brass inventory tag on each net. No net number is needed for shocking data sheets. The Id number field should be left blank. I will fill in this field with a unique number for each net lift or shocking event after all sampling is completed. This unique identifier helps in database management.

A separate master data sheet for each lake will also be provided. This data sheet will track the locations of the gear in each lake and look similar to the table below. If a net is moved during the course of the study, a new entry for that net number must be recorded.

Date	Net number	Gear type	Latitude	Longitude
04/10/01	BC100	Trap	45 10.55 N	81 13.66 W
04/10/01	BC151	Fyke	45 09.90 N	81 04.05 W
04/16/01	BC100	Trap	45 15.10 N	82 14.01 W

Scale envelopes

Scale envelopes must be filled out with the following information: date, species, length, and sex. It is not necessary to write the jaw tag number on the scale envelope. Lake can be stamped or written on the envelope back in the lab.

Species codes

Attached below is a list of 3-letter species codes to be used in this study. Codes for the target species (and 2 others) are printed on the bottom of the data sheet for quick reference.

Common species in Fish Col. System for Houghton, Burt, Crooked, Pickerel, and Michigamme

Species	3-letter Code
Black Bullhead	BLB
Black Crappie	BCR
Bluegill	BLG
Bowfin	BOW
Brown Bullhead	BRB
Burbot	BUR
Common Carp	CAR
Largemouth Bass	LMB
Longnose Gar	LNG
Muskellunge	MUS
Northern Pike	NOP
Pumpkinseed Sunfish	PSF
Rainbow Trout	RBT
Rock Bass	RKB
Smallmouth Bass	SMB
Walleye	WAE
White Sucker	CWS
Yellow Bullhead	YLB
Yellow Perch	YEP