Technical Fisheries Committee Administrative Report 2001: Status of Lake Trout and Lake Whitefish Populations in the 1836 Treaty-Ceded Waters of Lakes Superior, Huron and Michigan in 2000, with recommended yield and effort levels for 2001

A Report Submitted by the Modeling Subcommittee to the Technical Fisheries Review Committee

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Table of Contents

EXECUTIVE SUMMARY

Prepared by James R. Bence and Mark P. Ebener

In August 2000 the State of Michigan's Dept. of Natural Resources (MDNR), five tribes that are currently members of the Chippewa/Ottawa Resource Authority (CORA), and United States Dept. of Interior's U.S. Fish and Wildlife Service, negotiated an agreement (Consent Decree) to resolve their differences concerning allocation, management, and regulation of fishing in 1836 Treaty waters of lakes Superior, Michigan, and Huron (U.S. v. Michigan 2000). The Consent Decree states that mortality of lake trout shall be regulated with yield and effort limits throughout the 1836 ceded waters. In management units in which the state and tribes share commercial whitefish fisheries, the mortality of whitefish shall be regulated with yield limits. The Consent Decree provides specific guidelines on how these yield and effort limits should be calculated. A Modeling Subcommittee (MSC) of the Technical Fisheries Committee (TFC) was established and charged to develop the yield and effort limits called for in the Consent Decree.

We, the MSC, assessed population status and mortality rates for 16 different stocks of whitefish and ten stocks of lake trout that are at least partially within 1836 ceded waters. We also report on one whitefish area adjacent to treaty waters. Where feasible we developed and fit statistical catch at age models using a nonlinear modeling and statistics program (AD Model Builder, Otter Reseat Ltd.) to estimate age and year specific population abundance and mortality rates. In some cases the available data did not allow us to develop reliable population estimates in this way, and instead we have used a more descriptive approach. When statistical catch models could be developed the resulting estimates of abundance and mortality were combined in a spreadsheet with growth and maturity data for whitefish and lake trout in each stock or management unit, and recommended yield levels (upper bounds) were projected for calendar year 2001. Yield levels were obtained by either limiting mortality to a maximum rate, achieving a minimum spawning potential reduction in 2001, or projecting harvest for a specified level of fishing effort. The maximum allowable mortality rate on whitefish was 65%, while the maximum mortality rate (when applicable) on lake trout was either 40 or 45%. In some areas there was no total mortality rate limit for lake trout, and yields were tied to levels of fishing effort as part of a process for "phasing in" total mortality rate targets as specified in Consent Decree language. The target spawning potential reduction for whitefish ranged from 20 to 35%. Harvest limits were developed by solving for the allocation between state and CORA fisheries in stocks and management called for in the Consent Decree. Recommended harvest and effort limits for each whitefish stock or lake trout management unit are given below.

Species	Lake	Management unit	Yield limit or HRG (lb)	Gill net limit (ft)
Lake trout	Superior	MI-5	144,000	NA
		MI-6	25,000	0.6 million
		MI-7	139,000	11.0 million
	Michigan	MM-1,2,3	521,000	8.5 million
		MM-4	127,000	1.1 million
		MM-5	53,000	0.7 million
		MM-6,7	920,000	NA
	Huron	MH-1	72,000	5.9 million
		MH-2	12,000	NA
Lake whitefish	Superior	WFS-04	440,000	NA
		WFS-05	487,000	NA
		WFS-06	63,000	NA
		WFS-07	409,000	NA
		WFS-08	176,000	NA
	Michigan	WFM-01	796,000	NA
		WFM-02	357,000	NA
		WFM-03	953,000	NA
		WFM-04	590,000	NA
		WFM-05	235,000	NA
		WFM-06	151,000	NA
		WFM-08	3,305,000	NA
	Huron	WFH-01	327,000	NA
		WFH-02	620,000-650,000	NA
		WFH-03	220,000-250,000	NA
		WFH-04	787,000	NA
		WFH-05	461,000	NA

In Lake Superior there are self-sustaining stocks of lean lake trout and in that lake the assessment models and target mortality rates apply to these wild fish in three management areas (MI-5, MI-6, and MI-7). Because in MI-6 and MI-7 siscowet and lean yield are mixed in reports allowable total yield (including siscowet) can exceed the values in the above table by 14% and 35% respectively. In MI-6 recent mortality rates have been moderately above target rates and the recommended yield level represents some reduction in yield. In the other two areas recent mortality rates have been below targets, and increases in yield are possible. No stock assessment model was created for lake trout in MI-8 of Lake Superior because this was a deferred area. In MI-

8 current total lake trout abundance is lower and older ages are less well represented now than during the 1970s. It is promising, however, that recent mortality rates have been below 40%, and wild lake trout have reached a historic post collapse high in MI-8. There has been a general decline in size-at-age of lake trout across Lake Superior over the past 20 years, and tied to this a shift toward later maturity. These changes probably reflect changes in the abundance of prey fish, most of which are less abundant than 20 years ago. Competitive effects of siscowet lake trout may play a role.

In the Lake Huron and Lake Michigan management areas, wild lake trout are scarce and the assessment models and target mortality rates apply to stocked fish. Lake trout mortality rates in Lake Huron are above target rates. Phased in reductions in fishing mortality resulting from reduced commercial effort and a higher recreational minimum size limit will improve the situation in MH-1. Changes in fishery regulations will have relatively little effect in MH-2, as these are much less important than sea lamprey as sources of mortality there. Decreases in sea lamprey mortality are necessary in both areas in Lake Huron in order to meet mortality rate targets. This will depend upon success of the treatment of the St. Marys River in reducing sea lamprey abundance over the next several years.

Within Lake Michigan, only in the southern most area are lake trout mortality rates well below target rates, allowing the potential for substantial increases in yield. In northern Lake Michigan unit MM-123 recent mortality rates have been near target rates. However, projected declines in abundance mean that phased in yields, based on recent yield levels, could actually lead to higher mortality rates in the near term. In MM-4 and MM-5 recent mortality rates have been greater than target rates. Recommended yield levels for 2001 are below recent yield levels. Substantial decreases in commercial fishing effort and increases in the minimum size limit for the recreational fishery should help to achieve the mortality targets in the future. The effect of treatment of sea lamprey in the St. Marys River on lake trout mortality in Lake Michigan is not yet known.

In general, lake whitefish stocks have not been fished excessively hard in recent years. However, size at age has declined for most stocks over the past two decades. In a number of stocks this has been accompanied by a decline in fish condition (weight for a given length). These patterns are seen for some stocks on Lake Superior, but are most evident in Lake Michigan and Lake Huron management areas. Many stocks experienced a decline in recruitment near the end of the time series used in the assessments. Again this pattern was most prevalent in Lake Michigan and Lake Huron. In some notable cases (WFH-04, WFH-05, WFM-01, and WFM-02) estimated declines in size-at-age and recruitment were so pronounced that we projected declines in yields for 2001 for mortality set to the target rate, even though this represented an increase in fishing (and total) mortality from that of recent years. In WFH-04, WFH-05, and WFM-02 harvest regulation guidelines were set based on recent harvest levels. If the stock assessment results are correct, maintaining harvest at recent levels in the face of declining recruitment and growth will result in excessive mortality rates that will erode population abundance and further reduce yield. In addition, widespread declines in growth rates of lake whitefish are a concern, and gaining an ecological understanding of the phenomenon is important for refining management strategies. No summary report is included for WFM-07 even though it is a management zone within the 1836 Treaty waters. It has not been fished commercially since 1985 and there is no data available to model the lake whitefish populations in this zone.

In addition to providing assessments for each stock, we also recommend to the TFC ways to improve data collection and the models themselves. These recommendations include developing independent surveys to assess abundance of whitefish, delineating stock boundaries and movement patterns, determining under-reporting and discarding rates, directly estimating natural mortality, refining estimates of hooking mortality on lake trout and incorporating hooking mortality into all lake trout models, evaluating the most appropriate selectivity curves, refining our methods of estimating lake trout recruitment, and developing methods of estimating time varying catchability. The implementation of all these recommendations will by necessity need to take place over a period of years and will involve a significant and increased investment in staff time and other resources.

We also recommend a process that will allow us to provide timely stock assessment results. In part this is targeted at meeting deadlines imposed by the Consent Decree. This process involves using the projected yield for the last few months of the year based on historical patterns of the yield, modifying the commercial yield compilation process, and not waiting to use the most recent year's age composition data, when it cannot be available by the target date. These revised procedures for handling yield and age composition data are aimed at ensuring enough time after the data are available for analysis and modeling. We also believe that the parties should consider revisions to the time line for preparing stock assessments. First, we believe it would be more efficient if the whitefish stock assessment models and the lake trout models followed the same time schedule. Second, we think there needs to be more time between when the MSC provides initial yield and effort limits and when the TFC provides those numbers to the parties. This would allow the MSC time to review procedures for problematic estimates and to explore different options suggested by TFC.

STOCK ASSESSMENT MODELS

Prepared by James R. Bence

Overview

We used age-structured population models in two ways. The first was as a means to generate estimates of lake trout and lake whitefish abundance and mortality rates and describe how these have changed over time. The second was to project yield, harvest amounts and associated effort for 2001 that met criteria established as part of the Consent Decree. The first of these tasks was accomplished through applying statistical catch-at-age analysis (SCAA) as a means of estimating parameters determining fish abundance and mortality. These catch-age models operated with annual time steps and age-specific abundances and mortality rates were estimated for each year, through the last year for which data were available. Models were developed for stocks in each defined management area.

The second task built from the first, by projecting the estimated fish population forward through the 2001 fishing season, accounting for fishing and expected natural mortality and projecting the associated harvest and yield. The fishing mortality rates were adjusted in these projections to match upper bounds on fishing effort, fishery harvest, or total mortality while satisfying state and tribal allocation as defined in the Consent Decree.

Statistical Catch-Age Analysis

A catch-age model is fit to available data. These models consist of two components. The first is a submodel describing the population dynamics of the stock. The second is a submodel that predicts observed data, given the estimated population each year. The agreement between the model predictions and observed data is measured by statistical likelihood. Both the population and observation submodels include adjustable parameters. Any given set of these parameters corresponds to a specific sequence of stock abundances, mortality rates, and predicted data. The set of such parameters and associated stock dynamics and mortality rates) that maximize the likelihood (the maximum likelihood estimates) is taken as the best estimate.

Population submodel

The basic population model is quite simple. Except for the first age and first year, abundance-at-age at the start of each year is calculated recursively as the proportion of the cohort surviving from the start of the previous year:

$$N_{a+1,y+1} = N_{a,y} P_{a,y}$$

The proportion surviving is modeled as

$$P_{a,y} = e^{-Z_{a,y}}$$

where $Z_{a,y}$ is the instantaneous mortality rate for age-*a* and year-*y*. Total annual mortality (A=1-P) increases with increasing Z, but asymptotes at 1.0. Mortality targets are usually expressed in terms of *A*, but could be expressed in terms of the equivalent *Z*.

A primary challenge in developing the stock assessment models is to break the total instantaneous mortality rate into components of interest that can be calculated from a suite of parameters, which can be estimated from available data. All the models include fishing mortality (*F*) and background natural mortality (*M*). All lake trout models and whitefish models for Lake Huron include sea lamprey induced mortality (*ML*). In addition, fishing mortality is usually broken into two subcomponents. Thus:

$$Za,y = F(1)_{a,y} + F(2)_{a,y} + M_a + ML_{a,y}$$

where *F*(1) and *F*(2) represent two fishery components (e.g., gill-net and trap-nets, or sport and commercial). It is not possible to estimate all these rates as independent age and year specific components. To reduce the number of parameters, for each fishery component, the age and year specific fishing mortality rates are products of age-specific "selectivity" and year-specific "fishing intensity". In a purely separable model, selectivity is constant and thus each fishing mortality component is the product of an age (*S*) and year (*f*) effect:

$$F(i)a,y = S(i)_a \, f(i)_y$$

In many of our assessment models we have relaxed the separability assumption, to account for changing selectivity resulting from changes in size-at-age and fishery behavior or from other causes. To do this we modeled the relationship between selectivity and age with a four-parameter double logistic function that provides a flexible dome-shaped relationship between selectivity and age, and includes asymptotic increases with age as a special case. When time-varying selectivity was desired, one of the parameters of this function (that controls selectivity for younger ages) was allowed to vary gradually over time, following a quadratic function in time. Thus, selectivity patterns over time were described by the three parameters of the quadratic function and the three other parameters of the logistic function.

Fishing intensity is the fishing mortality rate for ages that have a selectivity of 1.0. Fishing intensities were not estimated freely, but instead were assumed to be proportional to effort, up to a multiplicative deviation:

$$f(i) = q(i)E(i)_y \zeta(i)_y$$

where *q* is catchability (the proportionality constant), *E* is observed effort, and ζ is the deviation. During model fitting, large estimated deviations were penalized. However, in cases where fishery effort was not considered to be very informative regarding fishing mortality (generally for the lake trout models), this penalty was reduced to near zero making the procedure nearly identical to estimating the f(i) directly.

The background natural mortality was assumed constant over time. For lake whitefish models and models of wild lake trout in Lake Superior, *M* is assumed constant for all ages modeled, whereas for other lake trout models, *M* is allowed to be higher for the younger ages. For the whitefish models *M* was assumed known based on a published relationship between *M* and growth model parameters and water temperature (Pauly 1980). For lake trout, while *M* was estimated during model fitting, deviations from prior estimates, based on the same relationship used for whitefish, were penalized.

Sea lamprey mortality rates were not estimated during model fitting. Instead they were calculated based on observed wounding (sum of A1-A3 marks), as was done by Sitar (1999). For a given size of fish, sea lamprey mortality was calculated by:

$$ML = w\frac{(1-p)}{p}$$

where w is the mean wounds per fish and p is an estimate of the probability of surviving an attack. Length specific wounding rates were converted to age-specific rates using an age-length key.

In summary, from 4 to 6 parameters are estimated during the fitting of the SCAA models to describe each fishery's selectivity pattern, and a year specific parameter was estimated associated with each fisheries fishing intensity. From no parameters (whitefish) up to two parameters (stocked lake trout) were estimated to describe background natural mortality. No additional parameters were estimated during model fitting to describe sea lamprey mortality, as these rates were calculated directly from wounding data.

To complete the population model and describe stock dynamics over time it is necessary to specify the initial numbers at age in the first year and the recruitment of the youngest age in each subsequent year. In the simplest cases each of these would be estimated as a free parameter during model fitting. We deviated from this simplest case in various ways. For stocked lake trout stocks, we modeled recruitment as the number of yearling equivalents actually stocked and calculated to move into an area (see Movement Matrices) multiplied by a year-specific "survival adjustment" factor. In this case the "survival adjustment" factors are estimated as parameters, with values deviating from 1.0 being penalized. For wild lake trout and for whitefish, recruitment was estimated as the product of the value expected from a Ricker stock-recruit function and a multiplicative deviation. Here the parameters of the Ricker function and the deviations were estimated, with deviations from 1.0 penalized. For stocked lake trout stocks, when age composition data was limited in earlier years, initial age compositions were based on the known number of lake trout that were stocked and a rough estimate of annual mortality, rather than being estimated during model fitting. For all the stocked lake trout stocks, initial numbers for year classes known not to be stocked were set to zero.

Movement Matrices and the calculation of yearling equivalents stocked

Assessment models for lake trout on Lakes Michigan and Huron were for hatchery-reared lake trout stocked into the lakes. The effective number of yearling lake trout stocked into a management unit that was being modeled each year was calculated as follows. First, we assumed that lake trout that significantly contributed to recruitment were stocked as either yearlings or fall fingerlings. The number of yearling equivalents were calculated as the number of yearlings stocked that year plus 0.40 times the number of fall fingerlings stocked the year before. Next the numbers stocked at various locations were adjusted for movement soon after stocking (before substantial spatially varying mortality comes into play.) This was done by apportioning fixed proportions of the numbers stocked at each location as being effectively stocked into each of the management areas (recruitment location) on the lake. These translations of numbers from stocking location to recruitment location were in the form of a "movement matrix." The numbers effectively stocked to a management unit (recruitment location) were then summed over the stocking locations. These effective numbers stocked were the input that was then adjusted upward or downward to account for year specific variations (see above).

The observation submodel

The observation submodel predicts numbers of lake trout or lake whitefish killed by each fishing component by age, and for the lake trout models catch per effort by age. Fishery kill is then converted into proportions-at-age and total number killed for comparison with data. Likewise, age-specific CPUE is converted into proportions-at-age and total CPUE for comparison with observed data.

Fishery kill is predicted using Baranov's catch equation:

$$C(i)a,y = \frac{F(i)_{a,y}}{Z_{a,y}} N_{ay} A(i)_{ay}$$

Note that no additional parameters, not already needed for the population submodel need to be estimated.

Survey catch-per effort was predicted assuming proportionality between population abundance and expected catch per effort, with selectivity following a logistic function of age:

$$CPE_{a,y} = q(s)S(s)_a N_{a,y}$$

where $q(s)$ is survey catchability, and $S(s)$ is survey selectivity. In some cases survey selectivity was allowed to vary over time in the same way as was fishery selectivity. The parameters of the survey selectivity function and survey catchability are new parameters that need to be estimated, which are not needed for the population submodel.

The Likelihood (defining the best fit)

For numerical and coding reasons it is convenient to maximize the likelihood by minimizing the negative log likelihood. Let L stand for the total log-likelihood. This is calculated as the sum of a set of K independent components:

$$L = L_1 + L_2 + L_3 + \ldots + L_K$$

Each component represents a data source or penalty, and the number of components varied among stocks and species. For each fishery that was included in the model there were three components: one for the total fishery kill each year, one for the fishery age-composition each year, and one for the effort deviations for each year. These likelihood components were calculated under the assumption that total fishery kill and effort deviations were log-normal and that the proportions-at-age were determined by a multinomial distribution. When a survey was available, this provided two likelihood components: one for the total CPUE (log-normal) and one for the age composition (multinomial). An additional component came from variation about stock-recruit functions or numbers based on stocking. In the calculation of this penalty term, the deviations were treated as log-normal. When variation about a prior estimate of

M was allowed, this contributed another term to the likelihood, and these variations were also assumed to be log-normal.

These various components were weighted by either the inverse of the variance associated with them (log-normal components) or the effective sample size (multinomial components). Here if *X* is log-normally distributed, variance refers to the variance of ln(*X*). In the case of effort deviations, in those cases where effort was assumed to provide little information on fishing mortality these components were down-weighted by an arbitrarily small value. The square root of the log-scale variances for the log-normal variables is approximately equal to the coefficient of variation (*CV*) on the arithmetic scale. In the case of a multinomial variable:

$$CV(p) = \sqrt{\frac{p(1-p)}{N}}$$

With these relationships in mind the modeling group considered information on the likely measurement error associated with the various data sources and specified default variances for each type of data, which were adjusted in cases where additional information was available on data quality.

In the case of variations about recruitment expected based on either the stock-recruit function or the numbers stocked, an iterative approach was followed during model fitting. An initial value for the standard deviation for variations about expected values was specified and the model was fit. Then the standard deviation of the resulting deviations was calculated. The model was refit, adjusting the value of the input standard deviation until the deviation between the standard deviation value specified prior to model fitting and the value calculated after model fitting was minimized. A minimum deviation was defined when the ratio of pre- to post-standard deviation was closest to 1.0.

Calculation of Recommended Harvest Regulation Guidelines, Total Allowable Catch (TAC), and Total Allowable Effort (TAE)

In general upper bound recommendations on yield and effort were calculated by first estimating population abundance-at-age at the start of the year and then adjusting fishing mortality either to meet mortality targets or to follow guidelines established in the Consent Decree for phasing in the targets. The resulting projection of yield or the effort associated with the fishing mortality then formed the basis of the recommendations.

We start by describing how the maximum amount of yield that could be taken, consistent with a specific upper bound on total mortality, was determined. This is the procedure that underlies the modeling group's recommendations regarding harvest regulation guidelines, TACs, and TAEs. We then describe how the procedures were modified to account for specific details that only apply to some areas. For some areas these details include how the target mortality rates were "phased-in" in the Consent Decree.

Target Mortality Rates

The Consent Decree specifies a "fully-phased in" upper bound target for total mortality (i.e., A = the proportion of the population that dies in a year). These rates are either 40-45% (depending on area) for lake trout or

65% for lake whitefish. As demonstrated by the Interagency Modeling Group (IMG) during the period that the Consent Decree was negotiated, these target rates require additional structure in order to be uniquely defined. This occurs because mortality rates vary among ages, so whether or not a population is above a mortality target depends upon what ages are considered and how the mortality rates for the different ages are combined.

Following the procedure of the IMG, we uniquely define mortality rates by making use of the idea of spawning stock biomass per recruit (SSBR). For lake trout, we first calculate spawning stock biomass for a default target mortality schedule. Any age-specific mortality schedule that produces as much spawning stock biomass as the default schedule is considered to be at or below the target mortality rate. The default schedule was to have only natural mortality (excluding sea lamprey-induced mortality) for ages below a specified age, and mortality equal to the target rate for ages equal to or above the specified age. The specified age at which the target rate first applied varied among areas depending upon maturity schedules and precedent.

For whitefish a somewhat different procedure was used to ensure both that an adequate amount of spawning stock was achieved per recruit and that more than one age was contributing substantially to the spawning population. This was done following a two-stage approach. First, overall fishing mortality rates were adjusted so that during projection period total annual mortality on the age experiencing the highest projected fishing mortality rate was equal to 65%. Then the spawning stock biomass per recruit was calculated for that scenario. Spawning potential reduction (SPR) is calculated by dividing this by the spawning stock biomass per recruit calculated assuming only background natural mortality. If SPR was less than 0.2, fishing mortality was decreased until SPR was equal to 0.2. The approach was developed by examining various different "rules" and ascertaining that this approach generally ensured more than one age class was contributing substantially to spawning. An SPR of 0.2 is aggressive by standards applied in other fisheries and reflects a perception that lake whitefish is generally robust to fairly high fishing rates.

Population at the Start of the Current Fishing Year

The SCAA stock assessment models for lake trout directly estimate population abundance at the start of 2000 and mortality rates during 2000. As a result they can be used in a straightforward fashion to estimate abundance for all ages other than the age of recruitment (the youngest age in the model) at the start of 2001. Recruitment was set at a value reflecting recent levels of recruitment (Lake Superior) or expected stocking. Note that assumed recruitment has little influence on calculations of harvest during 2001, as these fish are either not selected or only weakly selected by the fishery.

SCAA stock assessment models for lake whitefish are based on data through 1999 and can be used to estimate population abundance-at-age at the start of 2000 as was described for lake trout in 2001. Thus for lake whitefish there is one additional step, which is projecting the population from the start of 2000 through the start of 2001, without direct estimates of mortality rates during that year. For this projection age-specific mortality rates by source (i.e., trap-net and gill-net fishing mortality, sea lamprey-induced mortality, natural mortality) were set equal to rates averaged over the last three years for which estimates were made in the SCAA (1997-1999). Recruitment for both 2000 and 2001 was set to the average recruitment during the last 10 years for which SCAA estimates were available (1990-1999).

Projections during the 2001 Fishing Season

Starting with the estimates or projections of age-specific abundance at the start of 2001, the population was projected forward over the year accounting for age-specific mortality rates by source, using the same equations described above for the SCAA models. Numbers harvested-at-age were calculated by application of the Baranov catch equation. Harvest-at-age was converted to yield by multiplying numbers harvested-at-age by weight-at-age for the fishery and summing over ages.

In these calculations background natural mortality (M) was left at the same value as was used or estimated in the SCAA assessments. Although this is calculated as the average rate in recent years in most of the projection sheets, currently M is assumed constant over time in the assessment models. Depending upon species and area sea lamprey-induced mortality is either left at the average of the values in recent years of the SCAA (1997-1999) or is adjusted from that level to account for possible improvements in sea lamprey control due to treatment of the St Marys River (see alternative sea lamprey scenarios).

Fishing mortality rates by type (either sport and commercial or trap-net and gill-net for lake trout and lake whitefish respectively) were based on average rates in recent years. These average rates were adjusted to account for changes stipulated in the Consent Decree or known changes in fishing activity by multiplying the baseline age-specific rates by an appropriate multiplier. For example, if a gill-net fishery existed in an area prior to 2001 but did not in 2001, then in projecting whitefish yield the multiplier for gill-net fishery was set to zero. When fishing mortality is adjusted to account for a specified change in fishing effort, or when fishing effort was calculated to correspond with a specific level of fishing mortality rate, effort and fishing mortality were treated as being directly proportional. This basic approach to fishing mortality assumes that selectivity and catchability for each source will remain the same as it was on average in recent years. Detail on how fishing mortality rates were adjusted is covered in the next section.

Setting Fishing Mortality Rates for 2001

Details on how fishing mortality rates were adjusted depended on specific details of how an area was designated in the Consent Decree. We begin by considering lake trout. The simplest case was for areas calculated under the assumption of no phase-in and meeting Consent Decree mortality rate and allocation standards: MM-67, MM-5, MH-2, MI-5, and MI-7. This was accomplished by setting the multipliers for the recreational and commercial fisheries so as to simultaneously meet the mortality target (expressed in terms of SSBR) and the designated allocation. The process of finding the correct multipliers was expedited by making use of the Solver utility within Excel spreadsheets. In MM-67 the target mortality rate was 40% and the allocation was 90% state, 10% tribal. In MM-5 the target mortality rate was 45% and the allocation was 60% state and 40% tribal. In MH-2 the target mortality rate was 40% and the allocation was 95% state and 5% tribal. In MI-5 the target mortality rate was 45% and the allocation was 95% state and 5% tribal. In MI-7, the target mortality rate was 45% and the allocation was 30% state and 70% tribal. In the Lake Superior units (including MI-6 described below) adjustments were made as appropriate when reporting yield limits to account for the harvest of hatchery lake trout since tabled yield limits are taken as applying to all lean lake trout (wild and hatchery). This was necessary because hatchery lake trout, which were not part of the modeled population, do constitute a portion of the reported yields. The reported yield limits do not include siscowet lake trout. In MI-5 yield is reported separately for lean lake trout and this is not an issue. In MI-7 (and MI-6 described below) actual yield is allowed to go over the yield limit we table to account for the expected proportion of the yield made-up of siscowet. Thus total yield can by 114% and 135% of the yield limits for lean lake trout we table. (Note that the harvest and survey data was adjusted so it reflected only lean wild fish before it was compared with model predictions.) In all cases mortality rates were based on estimates of actual kill, while allocation was based on estimates of reported harvest (accounting for an estimate of under-reporting).

TACs for MH-1, MM-4, and MI-6 were calculated under a phase-in of effort guidelines for commercial effort, recreational regulations and associated harvest limits. The base period for commercial effort was 1997-1999. Hence we adjusted the average commercial fishing mortality rates by age during that period by multiplying them by the proportion of 1997-1999 large-mesh gill-net effort that was remaining after conversion of gill net fishers to trap nets. Recreational effort was left at the average of 1998-2000 values, adjusted for any change in size limits. There was no change in size limit for MM-4 and an increase to the 20" size limit was assumed for MH-1 and MI-6. Commercial TACs were based on predicted kill adjusted to account for any under-reporting and then the commercial yield was increased by 20%, in accord with the Consent Decree to provide a buffer for an increase in CPUE.

TAC calculations for MM-123 were more complicated than for other areas because of special provisions in the Consent Decree. Potential TACs were calculated three ways. First, TACs were calculated assuming that target mortality rates and allocation were fully phased in (40% mortality, Allocation 10% state: 90% tribal). Second, TACs were calculated using a phase in approach that differed somewhat from that specified for other areas. Finally TACs were calculated assuming the tribal TAC would be 450,000 pounds. Then, the largest tribal TAC among these three options was chosen, along with the associated state TAC. Note that the Consent Decree does not appear to provide guidance on how to phase in state harvest in this area. Thus for the second and third option we followed the same approach as we used in other areas (i.e., based on 1998-2000 effort and any regulation change). The phase-in approach was guided by the Consent Decree's requirement that the tribal TAC be set to the 1997-1999 harvest adjusted for any change in effort. We did this by first calculating a 2001 yield based on no-conversion of gear (1997-1999 effort) and then calculating taking into account the proportion of large-mesh gill net that was converted (as for phase in rules in other areas). The 1997-1999 tribal harvest was multiplied by the resulting ratio of (WITH CONVERSION) / (WITHOUT CONVERSION) yield to establish the phased in TAC. In contrast with MH-1, MM-4, and MI-6, there was no adjustment to buffer for changes in CPUE.

Lake whitefish recommendations with regard to yields were calculated generally following the approach used for fully phased-in lake trout areas. Details differed because of the different way that target mortality was defined for whitefish, and because for most areas there were no specified allocation between state and tribal fisheries (WFS-05 was an exception). In cases where there was no specified allocation the first step was to adjust the multipliers for trap net and gill net to account for known changes in fishing effort (generally changes expected to arise from conversions or movement of operations). This step merely adjusts the relative contributions of the two gears. Then an overall multiplier (that applied to both gears) was adjusted until the target mortality rate was reached for the fully selected age. When an allocation was specified the multipliers for the two gears were adjusted simultaneously (as was the case for lake trout) to match both mortality and allocation targets. At this point SPR was examined and if below 0.20 the fishing multiplier was reduced until SPR reached 0.20.

Alternative Sea Lamprey Scenarios

For MM-123, MM-4, MM-5, MH-1, and MH-2 the above TAC calculations for lake trout were done with different assumptions about sea lamprey control. In particular calculations were done for three options: (1) GLFC based assumptions regarding improved control (51% of 98-00 mortality in the Michigan units, 47% of the 98-00 sea lamprey induced mortality in the Huron units.), (2) 75% of the 98-00 baseline values, and (3) 100% (status quo) of the baseline values. For whitefish status quo (100% of baseline) was used.

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Sitar, S.P., Bence, J.R., Johnson, J.E., Ebener, M.P., Taylor, W.W. 1999. Lake trout mortality and abundance in southern Lake Huron. *N. Am. J. Fish. Manage*. 19: 881-900.

RECOMMENDATIONS AND FUTURE DIRECTIONS TO IMPROVE ASSESSMENTS

Prepared by James R. Bence and Mark P. Ebener

Data collection and processing

- Accurate and complete data on extractions and other deaths caused by fishing is essential if SCAA models are to produce reliable estimates. In this regard we need to gain a better understanding of the significance of subsistence fishery harvests and under reporting of lake trout in commercial fisheries, the extent of discarding by commercial fisheries, the significance of recreational fishing for whitefish, and discarding and associated hooking mortality within the recreational fishery. The possibility that there are differences in mortality of lake trout released by recreational anglers or from trap nets among areas should be investigated.

- Accurate prior estimates of M (natural mortality) are essential in most cases for SCAA models. In this regard existing tagging information and calculations of natural mortality for lake trout and whitefish need to reviewed. We strongly suspect the outcome of this review will reveal the need for additional tagging studies to estimate natural mortality rates.

- Currently CPUE is pre-processed using mixed-models to provide indices of abundance that are used by the models. The assumptions underlying these models could be further evaluated and this would likely lead to refinement of the approach and tailoring of the models to specific characteristics of the data in different areas.

- For lake trout, calculations of the effects of size limits and conversions of length-specific sea lamprey mortality to age-specific rates both depend upon the coefficient of variation in lengths about the mean length at age (CV). Currently this CV is assumed to be the same for all ages and stocks. This assumption needs to be evaluated.

- In Lake Michigan sea lamprey mortality rates are based on fall (instead of spring) marking and are based on rates summarized for wide length categories. The approach used on the other lakes (using spring data and estimating wounding as a smooth function of length) should be adopted when possible. We expect the availability of spring data will increase in the future in accord with the Lake Michigan lakewide assessment plan.

- Model results depend critically on "indices of abundance". In the absence of survey data the lake whitefish models make the strong assumption that fishery CPUE is proportional to abundance (equivalent to assuming that fishing mortality is on average proportional to fishing effort). We recommend the development and implementation of a sampling protocol for lake whitefish, and the investigation of historic data sets that might allow the inclusion of fishery independent survey data in whitefish models.

- The basis for stock boundaries and assumed movement or lack of movement between stocks needs further study. For lake trout the assumption that stocked fish move to an area and then become resident needs to be evaluated. Addressing these issues could involve a combination of marking/tagging and other stock identification approaches.

- We recommend the development a consistent protocol for sampling, processing and storing data. The approaches by which data used in the models were collected and processed need to be carefully and completely documented.

- Estimates of uncertainty for all data used in models should be developed.

- Improved approaches for estimating the most recent year's lake trout yield need to be investigated. At the time assessment models are constructed final numbers are not available. We believe yield for the last few months based on historical patterns is possible and may allow improve accuracy of data used in models. To facilitate this monthly reported catches will need to be checked each month and not at the end of the year.

Models

- The overall approach to modeling selectivity needs to be evaluated and alternative approaches should be considered. Currently we use a double logistic function of age. Alternative age-specific functions should be considered. In addition, approaches that model selectivity as a function of age need to be considered. Currently one of the parameters of the double logistic is allowed to vary over time following a polynomial in time. Alternative approaches (such as using a random walk for this variation) should be evaluated.

- Evaluate alternative approaches for whitefish models to current assumption that fishery catchability remains constant. Alternatives include allowing catchability to vary over time following a random walk or in response to population density.

- All lake trout models should be modeled to include hooking mortality. Currently this is only implemented for the MM-4 model.

- The performance of methods used for weighting likelihood components needs to be reviewed and potentially revised. It seems possible that some weighting factors could be estimated using statistical procedures.

- Current approaches to modeling and estimating recruitment need to be reviewed.

- Current harvest policies and possible alternatives need to be evaluated. This would involve stochastic simulations that take advantage of information developed from the SCAA assessment models and from information available from other published and unpublished studies.

- The approach of converting yield to numbers harvested for comparison with model predictions needs to be reviewed. This is based on the average weight of a harvested fish, which in some years is poorly estimated. An alternative is to convert predicted numbers harvested to yield based on weight-at-age, which may be better estimated.

- The maturity schedule is modeled as age-specific and constant in Lakes Michigan and Huron. It may be more appropriate to model this as dependent upon length or weight. Changes that could allow temporal changes should be evaluated.

- In Lake Huron lamprey induced mortality of lake whitefish is assumed to be constant over ages and years. It may be more appropriate to allow age and year specific rates. This should be evaluated and appropriate changes should be made.

Reporting and Time Frames

The timing of data availability and target dates for delivery can be summarized as:

Lake Trout

The Consent Decree sets the overall deadline for data availability on lake trout at March 1. The MSC moved this date to February 1 to allow additional time for calculating the harvest limits. There is some difficulty with this deadline as sometimes data needs extensive processing before it can be used in the models. Issues associated with individual data sources and plans for improving timeliness of assessments include:

1. Harvest/Yield:

   a. Commercial yield - Currently CORA and the state can't be ready by February 1, but can be ready by April 1. These numbers need to be made available in a more timely and accurate fashion.

   b. Recreational harvest – the state can provide these data by February 1.

2. <u>Biological data-commercial</u>:
These data can be available by February 1. We use age composition, mean weight in harvest, mean length at age, and composition of siscowets, wild and hatchery fish.

3. <u>Biological data-recreational</u>:
These data can be available by February 1, except Lake Superior age composition data can be available by February 15. If not ready by March 1 we will proceed without it and use the data the next year. We use age composition, mean weight of harvested fish, and composition of wild and hatchery fish.

4. <u>Stocking data</u>:
These data are provided by the USFWS and can be available by February 1.

5. <u>Survey data</u>:
   a. Survey CPUE – These data can be ready by February 1. The mixed model should be done by February 15. We will use the general linear model to estimate CPUE. This process is not extensive with stable sampling design. There have been some changes in sampling of survey stations.
   b. Age composition – These data can be ready by February 15, except in Lake Superior age composition can be provided by February 15. If not ready by February 15, we will proceed without the most recent year's data.
   c. Mean length and weight at age – These data can be ready by February 1 and the estimates of vonBertalanffy model can be updated by February 15.
   d. Sea lamprey marking – These data can be ready by February 1 and estimates of mortality can be ready by February 15.
   e. Maturity at age – These data can be ready by February 1. These are constants in Lakes Huron and Michigan and vary in Lake Superior.

Whitefish

The Consent Decree sets October 1 as the deadline for the previous year's data. These data can be available by July 1.

More general comments

- The MSC recommends that in addition to this status of the stocks report (short report), a second report for the 2001 assessments be written that documents and describes in detail the modeling methods used (long report). We recommend the short report be produced annually and include text describing any changes in the modeling process for a given region and species. The long report will be produced periodically following substantial changes in methods used to produce harvest limits.

- The MSC is concerned about the short-time frame between data availability and the deadline for lake trout harvest limits. The current approach should be continually reviewed, and after some experience is gained it might be preferable to either update the lake trout models every 2-3 years or update them with a one-year lag for some data sources.

- The lake whitefish models need to be updated annually. It would be more efficient if the date by which the results were due was moved forward to March 31, to correspond with the lake trout deadline (e.g. harvest limits based on 2001 data would be reported on March 31, 2003 instead of November 1, 2002).

- Age composition and commercial yield are the data that generally limit producing timely results. Above we have suggested an approach for providing commercial yield data sooner. In some areas age compositions may not be available when harvest limit calculations begin; we recommend proceeding without the most recent year's data in these cases.

STATUS OF LAKE TROUT POPULATIONS
Lake Superior

MI-5 (Marquette-Big Bay Stock)

Prepared by Shawn P. Sitar

Lake trout management unit MI-5 extends from Pine River Point (west of Big Bay) to Laughing Fish Point (east of Marquette), covering 924,017 acres. The management unit includes Stannard Rock, an offshore shoal about 45 miles north of Marquette, and is in both the 1836 (618,352 acres) and 1842 Treaty waters (305,665 acres). The 1836 Treaty waters extend east from the north-south line established by the western boundaries of grids 1130, 1230, 1330, 1430, and 1530. This unit has a wide bathymetric range with depths greater than 790 ft, but also contains 186,732 acres with bottom depths of 240 ft or less.

The only tribal commercial fishery is a large-mesh gill-net fishery that is centered around Marquette and Big Bay in 1842 Treaty waters. This fishery is mainly targeting lake whitefish with lake trout as bycatch. There has been some low level of tribal subsistence gill-net fishing in 1836 treaty waters. Tribal commercial yield of wild lake trout (in 1842 treaty waters) has ranged from 3,100 lb in 1986 to 42,100 lb in 2000. During 1996-2000, tribal yield averaged 17,000 lb and more than doubled from 15,900 lb in 1999 to 42,100 lb in 2000. Tribal large-mesh gill-net effort increased from 84,000 ft in 1986 to 489,000 ft in 2000.

Recreational harvest of lake trout comprises both charter and sport angler trolling. Most of this activity is based out of the port of Marquette, though some harvest occurs at Stannard Rock.

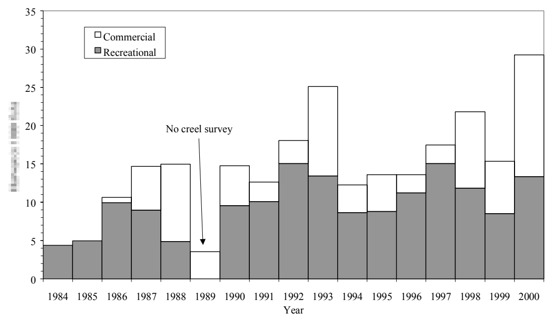

Figure 1. *Fishery harvest in MI-5 during 1984-2000. The tribal commercial fishery began in 1986. There were no recreational harvest estimates available prior to 1984 and for 1989.*

There are no seasonal restrictions on the sport fishery, though most of the fishery occurs during the months of May through October. Recreational harvest of wild lake trout has increased from 4,400 fish (22,000 lb) in 1986 to 13,400 fish (49,200 lb) in 2000 and has averaged 9,900 fish (39,600 lb) per year (Figure 1). Recreational effort has declined from 146,000 angler hours in 1986 to 50,000 angler hours in 2000.

Wild lake trout growth has declined since the mid-1970s. The decline in growth may be related to increased competition with siscowet lake trout and declines in prey fish abundance. Mean length at age 7 during 1975-1979 was 24.1 in (612 mm) and has decreased to 22.1 in (562 mm) during 1996-2000. The age at which 50% of females were mature has increased from age 7 during 1975-1979 to age 9 during 1996-2000. Abundance of age-3 and older wild lake trout increased over two-fold since 1975, though it has declined from the peak of about 1.4 million fish in 1997 (Figure 2). Total biomass of ages 3 and older lake trout averaged 3.3 million lb (1.5 million kg) during 1991-2000. Lake trout biomass declined from 4 million lb (1.8 million kg) in 1996 to 2.9 million lb (1.3 million kg) in 2000. Spawning stock biomass averaged 489,000 lb (222,000 kg) during 1991-2000.

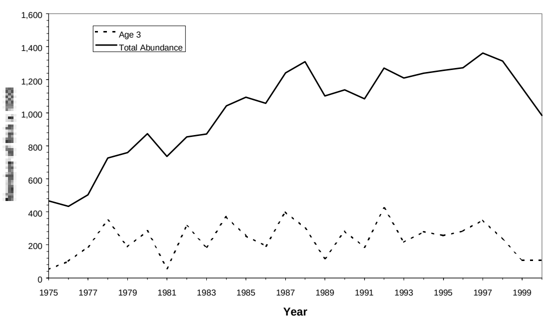

Figure 2. *Statistical catch-at-age model estimates of wild lake trout abundance in MI-5 from 1975 to 2000. Total abundance represents ages 3 and older fish.*

Although lake trout abundance has increased since the mid-1970s, spawning stock biomass has declined due to significant decreases in growth. This is likely to continue with declines in growth and increases in mortality rates.

During 1975-2000, sea lamprey-induced mortality was the dominant mortality source, although mortality from this source has declined since the mid-1980s (Figure 4). With the exception of 1988 and 2000, recreational fishing mortality has been higher than commercial fishing mortality since 1986. Average total annual mortality (A) for

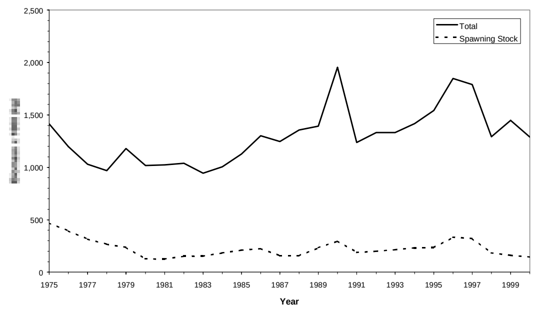

Figure 3. *Statistical catch-at-age model estimates of wild lake trout biomass in MI-5 from 1975 to 2000. Total biomass represents ages 3 and older fish.*

ages 6-11 lake trout has declined from 31% during 1975-1978 to 28% during 1998-2000. Spawning stock biomass produced per recruit during 1998-2000 has been above the target value indicating that mortality rates are low and there is good population reproductive potential. The recommended yield limit for 1836 Treaty waters was 144,000 lb, allocated as 137,000 lb for the state recreational

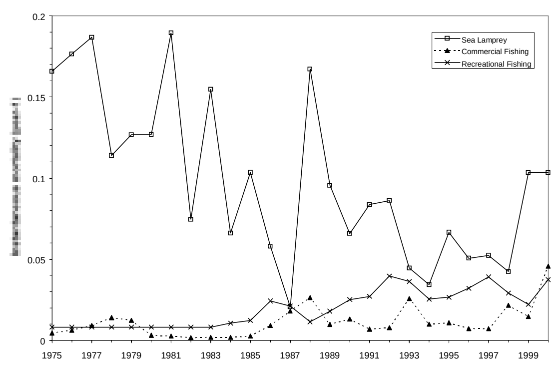

Figure 4. *Statistical catch-at-age model estimates of wild lake trout mortality rates in MI-5 from 1975 to 2000.*

fishery and 7,000 lb for the tribal commercial/subsistence fishery. This recommended yield limit is based on the target mortality rate of 40% defined in the Consent Decree, allocating 40% of the total yield to 1836 waters

Within 1836 waters, the recommended yield is allocated 95% to the state and 5% to the tribes. Note that this yield limit applies to wild and hatchery lake trout caught, whereas target mortality rates apply only to wild lean lake trout. In recent years wild lean lake trout compose approximately 90%of the total yield. In contrast with MI-6 and MI-7, yield is reported separately for lean and siscowet lake trout in MI-5 so the TAC applies directly to lean yield, with no allowance necessary for the siscowet portion of the catch. The recommended limit exceeds recent yields in 1836 Treaty waters (e.g., an average of 49,000 lb during 1998-2000), reflecting the fact that recent mortality rates have been well below target rates. Mortality rates are averaged for ages 6 to 11 fish.

Summary Status – MI-5 lake trout	
Female maturity	
Length at first spawning	20.1 in
Age at first spawning	6 y
Length at 50% maturity	23.8 in
Age at 50% maturity	9 y
Spawning stock biomass per recruit	
Base SSBR	3.49 lb
Current SSBR	1.06 lb
SSBR at target mortality	0.529 lb
Spawning potential reduction	
At target mortality	0.305
Average yield per recruit	0.322 lb
Natural mortality (M)	0.184 y^{-1}
Fishing mortality	
Fully selected age Commercial fishery (1998-2000)	7 y
Fully selected age Sport fishery (1998-2000)	8 y
Commercial fishery F (average 1998-2000, ages 6-11)	0.027 y^{-1}
Sport fishery F (average 1998-2000, ages 6-11)	0.030 y^{-1}
Sea lamprey mortality (ML) (average ages 6-11, 1998-2000)	0.083 y^{-1}
Total mortality rate (Z) (average ages 6-11, 1998-2000)	0.324 y^{-1}
Recruitment (age-3) (1991-2000 average)	244,000 fish
Biomass (age 3+) (1991-2000 average)	3,200,000 lb
Spawning biomass (1991-2000 average)	489,000 lb
Recommended yield limit in 2001	144,000 lb

MI-6 (Au Train-Munising stock)

Prepared by Shawn P. Sitar

Lake trout management unit MI-6 extends from Laughing Fish Point (east of Marquette) to Au Sable Point (east of Munising), encompassing 1,843,272 acres. The management unit includes Big Reef, an offshore reef complex about 20 miles northeast of Munising. This management unit contains the deepest waters of Lake Superior with soundings down to 1,460 ft, and only 185,003 acres of the total area is less than 240 feet.

The commercial fishery that harvests lake trout is a tribal large-mesh gill-net fishery and is centered east of Grand Island. This fishery mainly targets lake whitefish with lake trout as bycatch. Tribal commercial yield of wild lake trout peaked in 1989 at 29,800 lb and declined to an average of 11,700 lb during 1996-2000 (Figure 1). The tribal yield in 2000 was 12,600 lb, somewhat exceeding this recent average. In addition to wild lean lake trout the tribal fishery also harvests siscowet and hatchery lake trout. In recent years the wild lean yield has been 78% of the total, with 14% siscowet and 8% hatchery fish. Tribal large-mesh gill-net effort decreased from a peak of 3.6 million ft in 1983 to 1 million ft in 2000.

Recreational harvest of lake trout comprises fish caught by both charter and sport angler trolling. Most of the recreational harvest was from the Au Train Bay and Grand Island areas, although some harvest was also from Big Reef. Recreational harvest of wild lake trout has increased from 970 fish (5,300 lb) in 1987 to 4,700 fish (18,800 lb) in 2000 and averaged 4,000 fish (19,100 lb) per year. The sport harvest of wild lean lake trout represents 91% of the total recreational harvest of lake trout. The remainder was of hatchery origin (9%). Recreational effort has declined from 72,000 angler hours in 1988 to 32,000 angler hours in 2000.

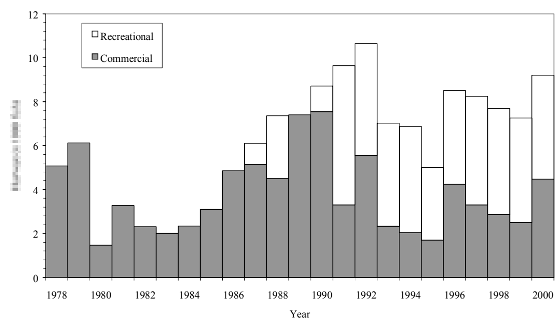

***Figure 1.** Fishery harvest in MI-6 during 1978-2000. There were no recreational harvest estimates available prior to 1987 and for 1989.*

Wild lake trout growth has declined since the mid-1970s. The decline in growth may be related to increased competition with siscowet lake trout and declines in prey fish abundance. Mean length at age 7 during 1975-1979 was 23.4 in (595 mm) and decreased to 21.8 in (554 mm) during 1996-2000. The age at which 50% of females were mature increased from age 8 during 1978-1982 to age 10 during 1996-2000. The decline in growth has strongly affected the reproductive potential of the population by decreasing spawning stock biomass.

Abundance of age-3 and older wild lake trout declined from 238,000 fish in

1988 to 150,000 fish in 2000. Recruitment at age 3 has declined during 1991-2000 and averaged 42,000 fish during this period. The decline in abundance is related to increases in

Figure 2. *Statistical catch-at-age model estimates of wild lake trout abundance in MI-6 from 1978 to 2000. Total abundance represents ages 3 and older fish.*

mortality rates starting in 1995 (see below) and the decline in recruitment (Figure 2). Total biomass of ages 3 and older lake trout has averaged 397,000 lb (180,000 kg) during 1991-2000. Biomass has declined from 463,000 lb (210,000 kg) in 1994 to 324,000 lb (147,000 kg) in 2000. Spawning stock biomass averaged 29,800 lb (13,500 kg)

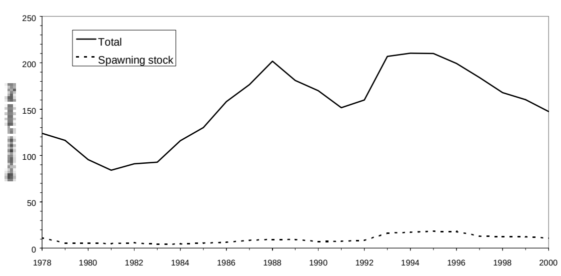

Figure 3. *Statistical catch-at-age model estimates of wild lake trout biomass in MI-6 from 1978 to 2000. Total biomass represents ages 3 and older fish.*

during 1991-2000 and represented 8% of total stock biomass.

During 1978-1990, sea lamprey and commercial fishing were the highest mortality sources for ages 6-11 lake trout in MI-6 (Figure 4). Recreational fishing mortality has been the highest mortality

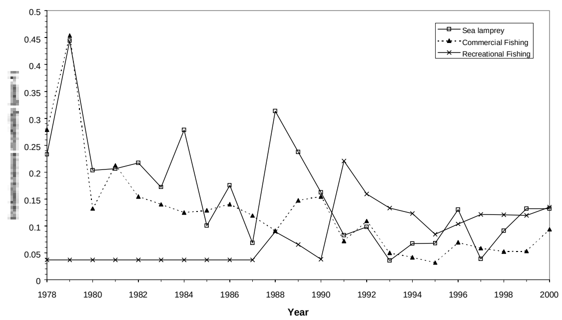

Figure 4. *Statistical catch-at-age model estimates of wild lake trout mortality rates in MI-6 from 1978 to 2000. Mortality rates are averaged for ages 6 to 11 fish.*

source in all years since 1991, except 1996 and 1999. During 1978-2000, total annual mortality (*A*) was the highest in 1979 at 67% and declined to 30% in 1995. Subsequently, *A* increased to 41% in 2000. The current spawning stock biomass per recruit (SSBR) estimate for MI-6 is below the target value, which indicates that mortality rates are exceeding the target *A* of 40%. The recommended yield limit for 2001 is 25,000 lb of which 14,000 lb is allocated for state recreational yield and 11,000 lb for tribal commercial yield. While mortality rates apply only to wild lean trout, the yield limit applies to all lean trout. In calculating the limit the Modeling Subcommittee assumed that 9% of the yield would be hatchery fish. The reported yield limit does not include siscowet lake trout, so yield is actually allowed to exceed this limit by 14% to allow for the portion of the yield that siscowet are expected to compose.

Furthermore, actual yields are allowed to exceed the limit by 20%, which reflects the phase-in provisions of the Consent Decree. In this unit the limit is based on a three year average of recent effort, adjusted for the effects of Consent Decree managed conversions of gill-net operations to trap nets and for changes in sport regulations. Because mortality was estimated to exceed the target, a 20" minimum size limit was put in place for the recreational fishery in 2001. This reduced the projected sport yield below recent yields and the yield recommended TAC.

Summary Status – MI-6 lake trout	
Female maturity	
Length at first spawning	21.6 in
Age at first spawning	7 y
Length at 50% maturity	24.7 in
Age at 50% maturity	10 y
Spawning stock biomass per recruit	
Base SSBR	4.26 lb
Current SSBR	0.49 lb
SSBR at target mortality	0.58 lb
Spawning potential reduction	
At target mortality	0.116
Average yield per recruit	0.659 lb
Natural mortality (M)	0.173 y^{-1}
Fishing mortality	
Fully selected age	
Commercial fishery (1998-2000)	9 y
Fully selected age	
Sport fishery (1998-2000)	10 y
Commercial fishery F	
(average 1998-2000, ages 6-11)	0.066 y^{-1}
Sport fishery F	
(average 1998-2000, ages 6-11)	0.125 y^{-1}
Sea lamprey mortality (ML)	
(average ages 6-11, 1998-2000)	0.118 y^{-1}
Total mortality rate (Z)	
(average ages 6-11, 1998-2000)	0.483 y^{-1}
Recruitment (age-3)	40,000 fish
(1991-2000 average)	
Biomass (age 3+)	397,000 lb
(1991-2000 average)	
Spawning biomass	28,700 lb
(1991-2000 average)	
Recommended yield limit in 2001	25,000 lb

MI-7 (Grand Marais stock)

Prepared by Shawn P. Sitar

Lake trout management unit MI-7 extends from Au Sable Point (west of Grand Marais) to Little Lake Harbor (east of Grand Marais), encompassing 987,224 acres. This management unit has complex bathymetry with many lacustrine ridges, trenches, and slopes. A total of 91,884 acres are at depths less than 240 ft.

The commercial fishery that harvests lake trout is a tribal large-mesh gill-net fishery that is mostly based out of Grand Marais. This fishery mainly targets lake whitefish with lake trout as bycatch.

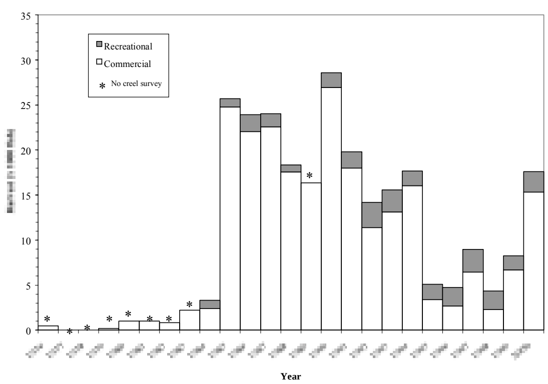

Figure 1. *Fishery harvest in MI-6 during 1978-2000. There were no recreational harvest estimates available prior to 1987 and for 1989.*

During 1975-2000, tribal commercial yield of wild lake trout peaked in 1990 at 117,000 lb and had declined to 21,200 lb in 1996. Subsequently, tribal yield increased, reaching 62,700 pounds in 2000. In recent years these yields of wild lean lake trout compose about 61% of the total lake trout yield, with the rest consisting of siscowet (35%) and hatchery lake trout (4%). Tribal large-mesh gill-net effort has shown the same temporal pattern as commercial yield, with a peak effort of 8.2 million ft of net in 1990.

There has not been a creel survey conducted in MI-7 since 1982 even though there is a recreational fishery. Sport harvest and effort in MI-7 were estimated roughly using the average sport CPUE and effort index ratio between MI-7 to MI-5 from MDNR creel mail survey data 1971-82 applied to MI-5 sport harvest and effort during 1984-2000. The estimates from this procedure indicate that recreational harvests in MI-7 are about half those of MI-6, and recent yields of wild lean lake trout are about 8,700 lb. This procedure requires strong and somewhat questionable assumptions, hence there is much uncertainty regarding the true magnitude of the recreational harvest in MI-7.

Wild lake trout growth has declined since the mid-1970s. The decline in growth may be related to increased competition with siscowet lake trout and declines in prey fish abundance. Mean length at age 7 during 1975-1979 was 23.6 in (600 mm) and decreased to 22.1 in (562 mm) during 1996-2000. The age at which 50% of females were mature increased from age 8 during 1975-1979 to age 10 during 1996-2000.

Abundance of age-3 and older wild lake trout averaged 725,000 fish during 1991-2000 and declined from 911,000 fish in 1996 to 576,000 fish in 2000 (Figure 2). Recruitment at age 3 averaged 180,000 fish during 1991-

2000, and has also declined since 1996. Spawning stock biomass averaged 111,300 lb (50,500 kg) during 1991-2000 and represented 6% of total stock biomass (Figure 3).

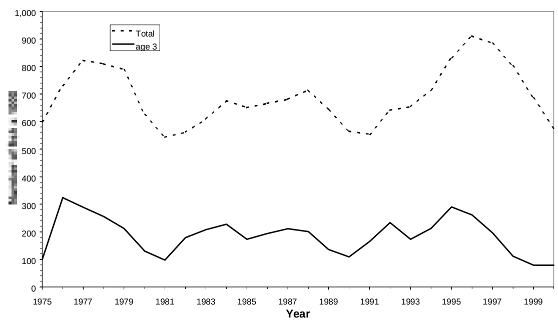

Figure 2. *Statistical catch-at-age model estimates of wild lake trout abundance in MI-7 from 1975 to 2000. Total abundance represents ages 3 and older fish.*

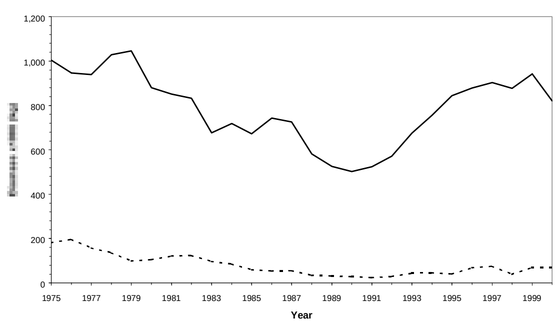

Figure 3. *Statistical catch-at-age model estimates of wild lake trout biomass for age-3 and greater (solid line) and spawning biomass (dashed line) in MI-7 from 1975 to 2000.*

Sea lamprey were the dominant mortality source for lake trout in MI-7 from 1975 to 1989 (Figure 4). Commercial fishing mortality increased significantly in 1985 and exceeded sea lamprey-induced mortality from 1990 to 1994. Commercial fishing mortality declined from 1995 to 1998, but has been increasing since 1998. During 1979 to 1990, total annual mortality (*A*) averaged 40% for ages 6-11 lake trout. From 1991 to 2000, average *A* was 32%. Total annual mortality has increased from 26% in 1997 to 35% in 2000.

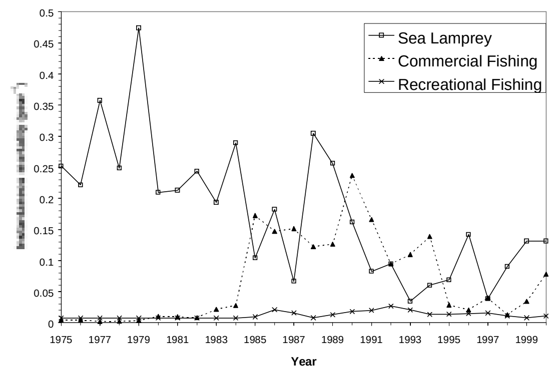

Figure 4. *Statistical catch-at-age model estimates of wild lake trout mortality rates in MI-7 (average for ages 6-11).*

The current spawning stock biomass per recruit (SSBR) estimate for MI-7 is above the target value, indicating that mortality rates are not exceeding the target. The recommended yield limit for the year 2001 is 139,000 lb of which 42,000 lb is allocated for state recreational yield and 97,000 lb for tribal commercial yield. These limits were calculated on the basis of the target mortality rate (*A*) of 40% and an allocation of 30% to the state and 70% to the tribes, in accord with the Consent Decree. These yield limits apply to all lean lake trout, but mortality targets only apply to wild lean lake trout. In determination of the yield limit it was assumed that 6% of the lean lake trout yield would be hatchery fish. The yield limit does not include siscowet lake trout so actual yields can exceed this limit by 35%, to allow for the portion of the yield that siscowet are expected to compose. The total yield limit exceeds yields from recent years reflecting the fact that mortality rates have been below target limits.

Summary Status – MI-7 lake trout	
Female maturity	
Length at first spawning	21.2 in
Age at first spawning	6 y
Length at 50% maturity	24.3 in
Age at 50% maturity	10 y
Spawning stock biomass per recruit	
Base SSBR	2.05 lb
Current SSBR	0.59 lb
SSBR at target mortality	0.48 lb
Spawning potential reduction	
At target mortality	0.288
Average yield per recruit	0.227 lb
Natural mortality (M)	0.210 y^{-1}
Fishing mortality	
Fully selected age Commercial fishery (1998-2000)	10 y
Fully selected age Sport fishery (1998-2000)	10 y
Commercial fishery F (average 1998-2000, ages 6-11)	0.042 y^{-1}
Sport fishery F (average 1998-2000, ages 6-11)	0.010 y^{-1}
Sea lamprey mortality (ML) (average ages 6-11, 1998-2000)	0.118 y^{-1}
Total mortality rate (Z) (average ages 6-11, 1998-2000)	0.379 y^{-1}
Recruitment (age-3) (1991-2000 average)	180,000 fish
Biomass (age 3+) (1991-2000 average)	1,700,000 lb
Spawning biomass (1991-2000 average)	112,000 lb
Recommended yield limit in 2001	139,000 lb

MI-8 (Southeastern Lake Superior)

Prepared by Kenneth J. Gebhardt

Lake trout management unit MI-8 is in southeastern Lake Superior (Figure 1), encompassing 744,945 acres of which 531,974 acres have bottom depths less than 240 feet. The occurrence of offshore, nearshore, large bay, river delta, and tributary confluence habitats makes this management unit and its fish communities unique. The unit also contains three historically important lake trout spawning reefs including Salt Point, Tahquamenon Island, and Iroquois Shoal. Production of wild recruit lake trout in this unit has been reported to be 321,983 fish annually. Because this area remains deferred no assessment modeling was done and no yield limits are recommended. This report describes the current and historical population characteristics of lean lake trout in this unit from 1970 to 2000, as well as information on the tribal commercial fishery from 1980 to 2000, based on both previous reports and new information.

Lake trout in MI-8 were deferred from rehabilitation efforts in 1985 as a result of treaty fishing negotiations among tribal, state, and federal fishery managers. At that time, it was agreed that the State of Michigan would annually stock 150,000 fall fingerlings in Whitefish Bay to supplement the existing tribal commercial fishery. As a result of the Consent Decree, lake trout stocking was discontinued and MI-8 was again deferred from rehabilitation efforts through 2020.

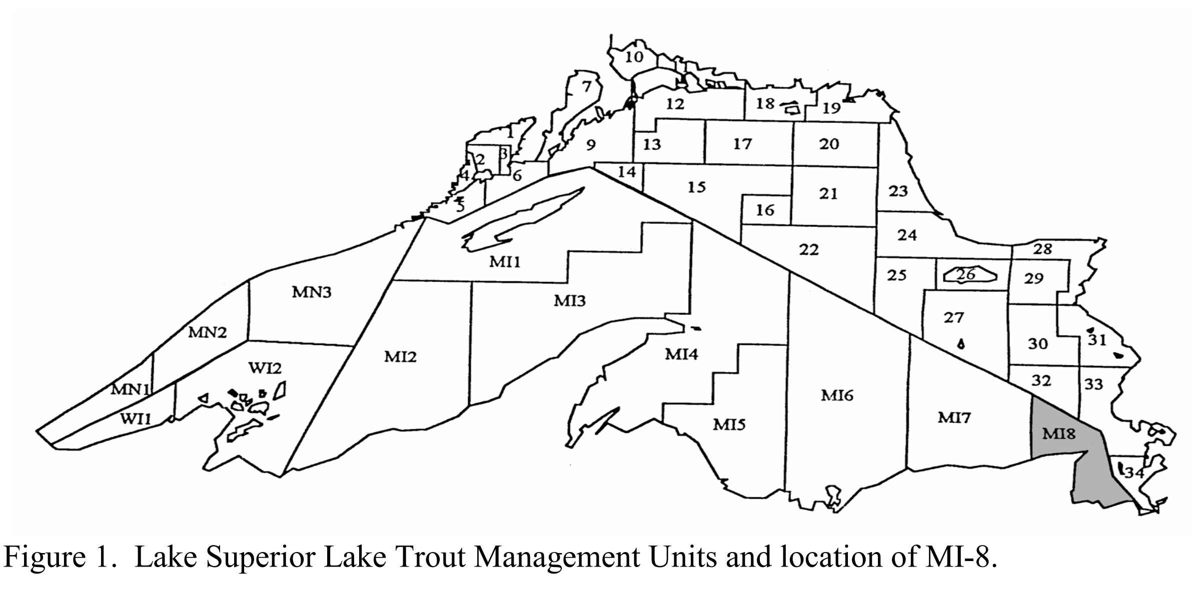

Figure 1. Lake Superior Lake Trout Management Units and location of MI-8.

MI-8 Commercial Harvest and Effort

Tribal commercial harvest of lake trout in MI-8 was variable during 1980-2000. Total reported yield from all gears ranged from a low of 1,900 pounds in 1980 to a high of 75,000 pounds in 1988 (Figure 2). Mean annual yield for all gears in 1995-2000 was 29,600 pounds. Tribal large-mesh gill-net effort increased from approximately 1.04 million feet in 1980 to 13.5 million feet in 1990 and decreased to 2.8 million feet in 2000 (Figure 3). Gill nets have consistently accounted for over 90% of the reported yield since 1980, although yield of lake trout by trap-net gear has increased annually since 1995 (Figure 2).

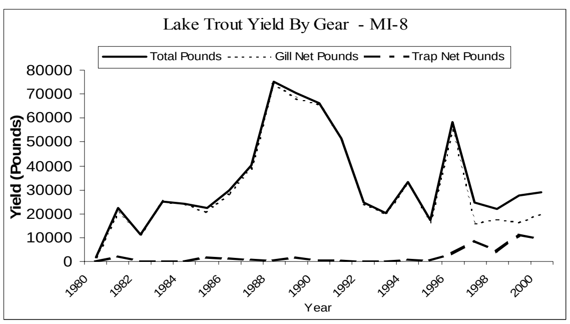

Figure 2. *Reported commercial yield of lake trout (pounds) in MI-8, 1980-2000..*

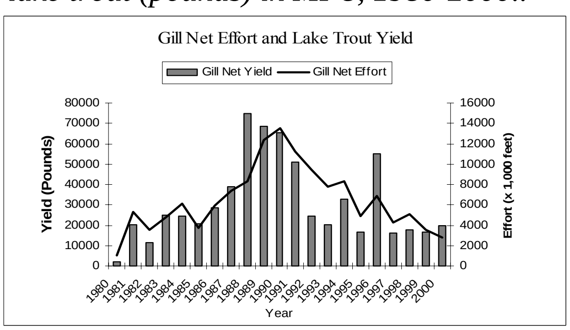

Figure 3. *Total reported tribal gill-net effort (1,000 feet) and lake trout yield (round pounds) in MI-8, 1980-2000.*

Historical and Current Abundance

Current abundance of lake trout in MI-8 is relatively low compared to historical levels. Between 1996 and 2000, CPUE of hatchery lake trout in spring assessments ranged from 2 fish per 1,000 feet of net in 1998 to nearly 12 fish per 1,000 feet in 2000 (Table 1). Wild lake trout CPUE has ranged from less than 1 fish per 1,000 feet in 1999 to an historical high of over 3 fish per 1,000 feet in 2000 (Table 1). Historical catch per effort of hatchery lake trout peaked at 54 fish per 1,000 feet in 1974, declined to 8 in 1975, further declined to 1 in 1981, then increased to 6 fish per 1000 feet in 1985 (Table 1). Wild lake trout CPUE was low in 1970-1977 and reached a high of 2 fish per 1,000 feet in 1979 and 1985 (Table 1)

Age and Length Characteristics of MI-8 Lake Trout

The age distribution of lean lake trout in MI-8 has shifted toward younger ages in comparison with historical observations. Age 3-8 fish are now predominant in the tribal large-mesh gill-net harvest and assessment fisheries compared to age 3-12 fish in 1970-1982. Age distribution of lake trout in the commercial harvest in Whitefish Bay expanded between 1993 and 1995, but older fish became scarcer in 1996 and 1997. Modal age of fish harvested in 1995, 1996, and 1997 was 4, 5, and 5 years, respectively. Modal age of lake trout caught in the assessment fishery was 4 years in 1999 and 2000.

Table 1. *Catch per effort (number of fish per 1000 feet of gill net lifted) for commercial (>= 17 inch) hatchery, wild, and large (>= 25 inch) lean lake trout, mean total length, and sea lamprey wounding rates in Michigan's Lake Superior management unit MI-8.*

Year	Catch per Effort: Hatchery	Catch per Effort: Wild	Catch per Effort: Large (>= 25 in)	Mean Length (in)	Sea Lamprey Wounding *: 25-28 (in)	Sea Lamprey Wounding *: >= 17 (in)
1970	19.7	0.2	1.6	20.6	20.1	7.0
1971	22.0	0.4	1.0	20.5	11.8	19.6
1972	11.3	0.2	0.9	21.4	9.2	4.8
1973	32.7	0.1	-	-	-	-
1974	54.4	0.1	5.9	21.7	-	-
1975	8.3	0.5	3.3	23.3	-	-
1976	3.6	0.7	-	-	-	-
1977	2.8	0.8	-	-	-	-
1978	-	-	-	-	-	-
1979	1.4	2.1	0.1	20.0	0.0	0.0
1980	12.0	1.1	0.3	20.9	0.0	2.0
1981	1.1	0.5	0.2	21.1	18.3	5.6
1982	3.5	1.1	0.3	20.2	31.1	8.4
1983	-	-	-	-	-	-
1984	-	-	-	-	-	-
1985	6.0	2.1	0.3	20.1	24.1	7.4
1986	-	-	-	-	-	-
1987	-	-	-	-	-	-
1996	8.5	1.8	0.3	20.3	0.0	3.8
1997	4.3	2.2	0.6	21.4	0.0	9.2
1998	1.9	2.8	0.1	20.6	0.0	0.0
1999	5.0	0.4	0.0	18.4	0.0	3.7
2000	11.6	3.3	0.2	19.2	50.0	4.6

*Sea lamprey wounding expressed as mean total number of A1, A2, and A3 wounds per 100 lake trout

Length distribution of lake trout in MI-8 has also recently shifted toward smaller fish. The proportion of fish larger than 19.6 inches (500 mm) decreased from nearly 70 percent of the commercial harvest in 1995 to less than 40 percent in 1997. Length distribution of assessment caught fish has also shifted toward smaller fish. In 1996-1998, fish larger than 19.6 inches comprised nearly 70 percent of the catch compared to less than 45 percent in 1999 and 2000. Mean total length of lake trout in the 1970-1985 assessment fisheries ranged from 20.1 to 23.3 inches. Mean length of assessment caught fish in 1997-2000 ranged from 18.4 to 21.4 inches (Table 1).

Immature lake trout are prevalent in the commercial harvest and assessment fisheries, with only 22-27 percent of the females in the 1996 and 1997 commercial fisheries and 14 percent of females captured in the 1999 and 2000 spring assessments being mature. Commercial and assessment information collected in 1993-2000 indicated that the proportion of mature females increased from 0 percent at age 3 to 50 percent at age 8. Thus the low percentage mature reflects the general dominance of the catch of younger fish.

Mortality of Lake Trout in MI-8

The Lake Superior Technical Committee recommended (in its 1996 lake trout restoration plan) that fishery management agencies should limit the harvest of lake trout, especially those larger than 24 inches to a point where total annual mortality of adults is less than 45%. This is based upon within year age-frequency catch curves using spring gill-net assessment survey data. Total annual mortality of lake trout based upon combined years in 1998-2000 was 40%, in comparison with a rate of 54% for 1996-1998. In contrast with these rates based on assessment samples, total annual mortality based on age 5-9 lake trout sampled from the commercial fishery in 1993-1997 was only 29 percent. Thus, for the most recent years estimated mortality appears to have fallen below the rate recommended to restore self-sustaining populations in Lake Superior. Such low rates, however, have not yet been sustained for extended periods, and this is reflected in the dominance of younger and smaller fish in the catches.

Sea lampreys remain an important source of lake trout mortality in MI-8. Wounding rates of lake trout harvested in tribal commercial gill-net fishery increased annually between 1994 and 1997. Recently, wounding rates of fish captured during spring assessments were highest in 1997, decreased to 0 wounds per 100 fish in 1998, but increased again 1999 and 2000 (Table 1).

Summary for MI-8

Although lake trout abundance, especially of larger mature fish, remains low in MI-8, the most recent estimate suggests that mortality rates are not excessive. Furthermore, wild lake trout have reached a post-collapse peak. Whether these positive signs lead to progress toward lake trout restoration will depend upon future fishery management decisions and resulting mortality rates.

Lake Huron

MH-1 (Northern Lake Huron)

Prepared by Aaron P. Woldt

Lake trout management unit MH-1 is located in northern Lake Huron and extends from the Mackinaw Bridge south to the border between grids 607 and 608, encompassing statistical district MH-1 and adjacent Canadian waters (Canadian management area 4-1). The management unit has a wide bathymetric range with areas in grids 407 and 408 as deep as 426 ft. The Michigan portion of this unit lies completely within 1836 Treaty waters, covering 1,017,640 acres of which approximately 681,720 acres are less than 240 feet in depth. On the Michigan shore this unit encompasses the ports of Mackinaw City, Cheboygan, Hammond Bay, and Rogers City. The St. Mary's River, connecting Lakes Superior and Huron, flows into Lake Huron in grid 306. The St. Marys River supports large spawning runs of sea lamprey and until recently the resulting larval populations were untreated and contributed substantial numbers of parasitic-phase sea lamprey to the lake. Comprehensive treatment of the river by the Great Lakes Fishery Commission's control agents should reduce the number of sea lamprey produced in the St. Marys River in the future. The majority of Lake Huron's historically important lake trout spawning reefs and shoals are located in MH-1. The Drummond Island Refuge is located in grids 307, the northern ½ of grid 407, and Michigan waters of grids 308, 408, 409, and 410, and covers 177,840 acres of the 1836 Treaty waters. Retention of lake trout in the refuge is strictly prohibited.

There is little or no natural recruitment of lake trout in northern Lake Huron. As a result, nearly all the lake trout harvest is comprised of hatchery fish. The United States Fish and Wildlife Service annually plants lake trout in MH-1. From 1996 to 2000, approximately 240,000 yearling lake trout were planted annually in MH-1. Under the Consent Decree, stocking will be increased in MH-1 to levels prescribed in the Lake Huron Committee's Lake Trout Rehabilitation Guide.

Both commercial and recreational lake trout fisheries exist in MH-1. Tribal commercial fishers deploy trap nets and large-mesh gill nets (>11 cm stretch) that target lake whitefish and salmon, and small-mesh gill nets (≈ 6 cm stretch) that target bloater chubs. Lake trout are caught in these fisheries as bycatch and can be marketed by tribal fishers. No state-licensed commercial fishers operate in MH-1. The Consent Decree prohibits state-licensed commercial fishing north of the 45th parallel. Previous to August 2000 one state-licensed fisher, Gauthier and Spaulding Fisheries, operated a trap-net operation in MH-1. This fisheries targeted lake whitefish and was not allowed to market lake trout bycatch. All lake trout were returned to the water, regardless of condition.

Because there is a substantial commercial fishery for lake trout in Canadian waters adjacent to MH-1, although few lake trout have been stocked there, this region was included in the assessment model. This means that lake trout extractions from Canadian management area 4-1 were included in the data and estimates of yields and recruitment into this area (primarily the result of movement from other areas) was also included. From 1996 to 2000, tribal commercial yield of lake trout averaged 141,000 lb, while Canadian commercial yield averaged 22,000 lb. The majority of tribal lake trout yield came from the large-mesh gill-net fishery. Tribal large-mesh gill-net effort averaged 13.4 million ft from 1996 to 2000, while Canadian large-mesh gill-net effort averaged 2.7 million ft.

The recreational fishery in MH-1 is composed of both charter and non-charter fishermen. Lake trout are frequently caught as bycatch by salmon fishermen trolling at or near the surface, but some anglers target lake trout by fishing the lower parts of the water column. A limited number of subsistence fishing permits are also issued to tribal members in 1836 Treaty waters. Recreational harvest represents a small portion of the total fishery harvest in MH-1 (Figure 1). From 1996 to 2000, recreational yield of lake trout averaged 8,180 lb (3,700 kg).

Instantaneous mortality rates have been variable and relatively high in northern Lake Huron (Figure 2). From 1977 to 1990, commercial fishing mortality was the leading source of lake trout mortality. After 1990, commercial fishing mortality decreased as sea lamprey-induced mortality increased. Sea lamprey were the largest source of lake trout mortality in the 1990s, until 1998 when sea lamprey-induced mortality decreased. From 1996 to 2000, lamprey-induced instantaneous mortality averaged 0.30 and commercial fishing instantaneous mortality averaged 0.19. Recreational fishing mortality was low in all years relative to commercial fishing mortality in northern Lake Huron (Figure 2).

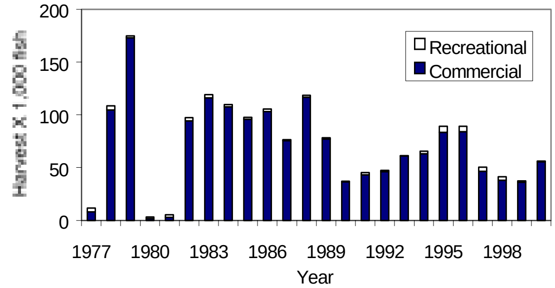

***Figure 1.** Harvest of lake trout by fishery in MH-1.*

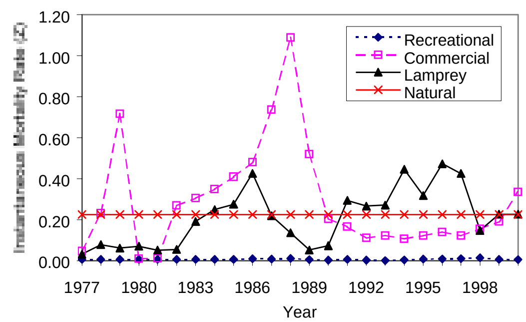

***Figure 2.** Instantaneous mortality rates of lake trout (average for ages 6-11) in MH-1.*

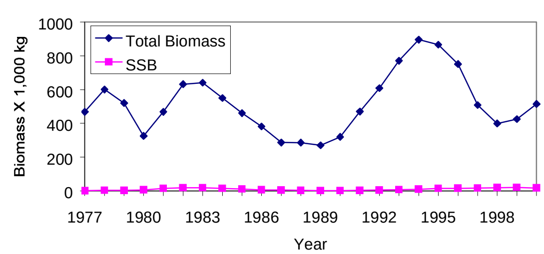

***Figure 3.** Lake trout biomass and spawning stock biomass (SSB) in MH-1.*

The high rates of both sea lamprey-induced and commercial fishing mortality caused the age structure in northern Lake Huron to be truncated just before the age of first maturity. As a result, spawning stock biomass is extremely low in northern Lake Huron, and total lake trout biomass varied around a 20-year average of 1,144,780 lb (518,000 kg) (Figure 3).

The Modeling Sub-committee of the TFC recommends a lake trout harvest limit of 72,000 lb for MH-1 in 2001. This harvest was calculated based on the phase-in described in the Consent Decree. In particular, this was based on the average effort during the previous three years, either adjusted for gill-net operations converted to trap nets under provisions of the Consent Decree (tribal commercial fishery) or changes in regulations (state recreational fishery). There has been substantial conversion of gill-net effort in this unit and a 20” minimum size limit (increased from 10") was implemented for the recreational fishery in 2001. Based on these calculations the total yield was allocated 3,000 lb (1,362 kg) to the state and 69,000 lb (31,326 kg) to the tribes. In calculating these yields we used "status quo" sea lamprey mortality levels (average rate observed in recent years), because of the uncertainty of the effects of the St. Marys River lamprey treatments. Harvest reductions along with potential reductions in sea lamprey mortality due to the treatment of the St. Mary’s, should allow the lake trout population in MH-1 to progress towards rehabilitation, although projected mortality rates during 2001 are still projected to exceed the fully phased in target rate of 45%.

Summary Status – MH-1 lake trout	
Female maturity	
Length at first spawning	16.4 in
Age at first spawning	4 y
Length at 50% maturity	23.7 in
Age at 50% maturity	8 y
Spawning stock biomass per recruit	
Base SSBR	2.49 lb
Current SSBR	0.141 lb
SSBR at target mortality	0.295 lb
Spawning potential reduction	
At target mortality	0.119
Average yield per recruit	0.518 lb
Natural mortality (M)	0.225 y^{-1}
Fishing mortality	
Fully selected age	
Commercial fishery (1998-2000)	5 y
Fully selected age	
Sport fishery (1998-2000)	6 y
Commercial fishery F (average 1998-2000, ages 6-11)	0.227 y^{-1}
Sport fishery F (average 1998-2000, ages 6-11)	0.008 y^{-1}
Sea lamprey mortality (ML) (average ages 6-11, 1998-2000)	0.200 y^{-1}
Total mortality rate (Z) (average ages 6-11, 1998-2000)	0.660 y^{-1}
Recruitment (age-1) (1991-2000 average)	544,000 fish
Biomass (age 3+) (1991-2000 average)	1,230,000 lb
Spawning biomass (1991-2000 average)	29,000 lb
Recommended yield limit in 2001	72,000 lb

MH-2 (North-central Lake Huron)

Prepared by Aaron P. Woldt

Lake trout management unit MH-2 is located in north-central Lake Huron. It includes statistical district MH-2 (grids 409-410, 509-512, 608-614, 709-715, 809-815, and 909-915 for a total of 1,521,520 acres) as well as adjacent Canadian waters (areas 4-2, 4-3, and 4-7 for a total of 1,526,460 acres). Michigan waters of the MH-2 unit include both 1836 Treaty waters (723,710 acres) and non-treaty waters (797,810 acres), divided by a line running north-east from the tip of North Point to the international border. The Michigan ports of Presque Isle and Alpena are contained in this unit. The St. Marys River, connecting Lakes Superior and Huron, flows into northern Lake Huron in grid 306, to the north of this unit. The St. Marys River supports large spawning runs of sea lamprey and until recently the resulting larval populations were untreated and contributed substantial numbers of parasitic phase sea lamprey to the lake. Comprehensive treatment of the river by the Great Lakes Fishery Commission's control agents should reduce the number of sea lamprey produced in the St. Marys River in the future. The management unit has a wide bathymetric range, with areas in grids 714 and 814 deeper than 690 feet, and a total of 202,540 acres of 1836 Treaty waters with bottom depths of 240 feet or less. This management unit contains a limited number of historically important lake trout spawning reefs and shoals. These reefs are located near Middle Island, North Point, and Six Fathom Bank. The Six Fathom Bank Refuge is located in the eastern half of grids 913 and 1013, grids 914 and 1014, and Michigan waters of grids 915 and 1015 covering 251,940 acres. Canadian waters adjacent to the refuge are a commercially protected area where commercial fishermen are prohibited from fishing in waters shallower than 40 fathoms. Recreational fishers may harvest lake trout in Canadian waters adjacent to the refuge, but few travel the long distance offshore. Approximately ½ of the refuge lies in MH-2 (118,560 acres), and retention of lake trout in the refuge is strictly prohibited.

There is little or no natural recruitment of lake trout in north-central Lake Huron. Only one site off North Point has yielded consistent, yearly production of wild juvenile lake trout in MH-2. As a result, nearly all lake trout harvest is comprised of hatchery fish. The United States Fish and Wildlife Service annually plants lake trout in MH-2. From 1996 to 2000, approximately 272,000 yearling lake trout per year were planted annually in near-shore areas of MH-2, and 220,000 yearling lake trout were planted annually on Six Fathom Bank. Approximately 156,000 yearling lake trout were planted annually in Canadian management area 4-3 from 1996 to 2000. Under the Consent Decree, stocking will be increased in MH-2 to levels prescribed in the Lake Huron Committee's Lake Trout Rehabilitation Guide.

In contrast to MH-1, there is no commercial harvest of lake trout in Michigan waters of MH-2. As of

August 2000, tribal commercial fishers may deploy trap nets that target lake whitefish in 1836 waters of MH-2. This fishery is not allowed to market lake trout bycatch. Two state-licensed commercial fishing operations (Gauthier and Spaulding Fisheries, and Rochefort Fisheries) operate trap nets targeting lake whitefish in MH-2 south of the 45th parallel. These operations are not allowed to market lake trout bycatch. All lake trout are returned to the water, regardless of condition. Prior to the signing of the Consent Decree, both state-licensed fisheries operated trap nets north of North Point. These fisheries were moved south of the 45th parallel to accommodate the new tribal trap-net operations as stipulated in the Consent Decree.

There is a substantial commercial fishery for lake trout in Canadian waters adjacent to MH-2 (areas 4-2, 4-3, and 4-7) that we included in our assessment. From 1996 to 2000, total Canadian commercial lake trout yield in these areas averaged 27,270 lb (12,500 kg) per year. The majority of this yield came from the large-mesh gill-net fishery. Canadian large-mesh gill-net effort averaged 4.8 million ft per year from 1996 to 2000.

The recreational fishery in MH-2 is composed of both charter and non-charter fishermen, almost entirely within Michigan waters. Lake trout are frequently caught as bycatch by salmon fishermen trolling at or near the surface, but some anglers target lake trout by fishing the lower parts of the water column. A limited number of subsistence fishing permits are also issued to tribal members in 1836 Treaty waters. The magnitude of recreational

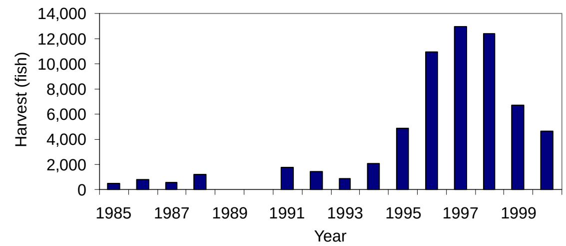

Figure 1. *Recreational harvest of lake trout in MH-2. No creel data available 1989-90.*

harvest varies from year to year and has averaged 9,500 fish from 1996 to 2000 (Figure 1). From 1996 to 2000, recreational yield of lake trout averaged 37,570 lb (17,000 kg).

The dominant source of mortality for lake trout in MH-2 was sea lamprey (Figure 2). Sea lamprey-induced mortality was greater than all other mortality sources from 1984 to 2000 with the exception of 1987 and 1990, when natural mortality was the largest single mortality source (Figure 2). Sea lamprey mortality rates have been cyclic in north-central Lake Huron, reaching peaks in 1989, 1994, and 1997 (Figure 2). From 1996 to 2000, sea lamprey-

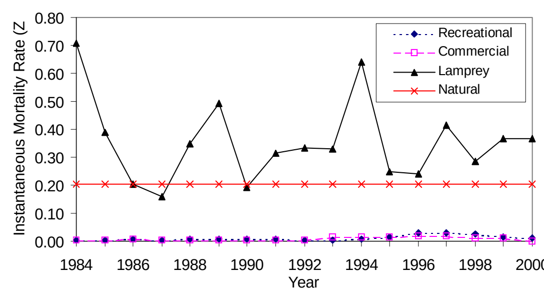

Figure 2. *Instantaneous mortality rates of lake trout ages 6-11 in MH-2.*

induced mortality averaged 0.34. Recreational and commercial fishing mortality were low in all years relative to lamprey-induced mortality (Figure 2).

The high rate of lamprey-induced mortality caused the age structure in north-central Lake Huron to be truncated just before the age of first maturity. As a result, spawning stock biomass is low in north-central Lake Huron (Figure 3). Total lake trout biomass has steadily increased since 1984, averaging 1,856,400 lb (840,000 kg) from 1996 to 2000 (Figure 3); however, the majority of this biomass is young, immature, hatchery fish.

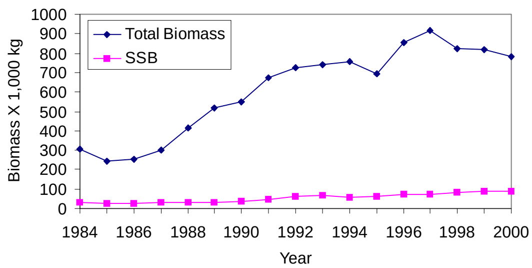

Figure 3. *Lake trout biomass and spawning stock biomass (SSB) in MH-2.*

Following the specific protocol outlined in the Consent Decree, the MSC determined that even closing the fishery would not bring mortality rates below target levels. These calculations were done assuming status quo sea lamprey mortality levels, because of the uncertainty of the effects of the St. Mary's River lamprey treatments. Instead, the TFC recommends a lake trout harvest limit of 12,000 lb for MH-2 in 2001. This harvest is allocated as 11,000 lb to the state and 1,000 lb to the tribes. These relatively modest yields have a minor effect on total mortality and avoid serious disruption of the fishery. A true zero fishing mortality policy would even require closing of the trap-net fishery because of the minor associated bycatch. The recreational yield was set at 60% of the 2000 yield. This was the projected yield with similar effort as in 2000 but with the new 20" minimum size limit in effect. Tribal yield was determined from this based on the allocation specified in the Consent Decree. Although the reduction in yield should reduce mortality a small amount, substantial progress will depend upon successful sea lamprey control.

Summary Status – MH-2 lake trout	
Female maturity	
Length at first spawning	17.8 in
Age at first spawning	4 y
Length at 50% maturity	24.7 in
Age at 50% maturity	7 y
Spawning stock biomass per recruit	
Base SSBR	4.59 lb
Current SSBR	0.432 lb
SSBR at target mortality	0.743 lb
Spawning potential reduction	
At target mortality	0.162
Average yield per recruit	0.115 lb
Natural mortality (M)	0.204 y^{-1}
Fishing mortality	
Fully selected age	
Commercial fishery (1998-2000)	6 y
Fully selected age	
Sport fishery (1998-2000)	6 y
Commercial fishery F	
(average 1998-2000, ages 6-11)	0.008 y^{-1}
Sport fishery F	
(average 1998-2000, ages 6-11)	0.018 y^{-1}
Sea lamprey mortality (ML)	
(average ages 6-11, 1998-2000)	0.341 y^{-1}
Total mortality rate (Z)	
(average ages 6-11, 1998-2000)	0.571 y^{-1}
Recruitment (age-1)	573,000 fish
(1991-2000 average)	
Biomass (age 3+)	1,600,000 lb
(1991-2000 average)	
Spawning biomass	155,000 lb
(1991-2000 average)	
Recommended yield limit in 2001	12,000 lb

Lake Michigan

MM-123 (Lake Michigan-Northern Treaty Waters)

Prepared by Jory L. Jonas, James R. Bence, Erik J. Olsen, and Randall M. Claramunt

Lake trout management unit MM-123 is made up of statistical districts MM-1, MM-2 and MM-3 and encompasses Michigan's waters of northern Lake Michigan and northern Green Bay. This management unit covers 5,000 square miles. Water depths in the northern management unit are for the most part less than 150 feet, and approximately 3,800 square miles are less than 240 feet. Depths do, however, reach over 550 feet in the southern portions of the unit. Many historically important lake trout spawning reefs are located in this unit. The unit also contains many islands including the Beaver Island complex (Beaver, Hat, Garden, Whiskey and Squaw Islands), North and South Fox Islands, and Gull Island. Another series of islands form a line separating Green Bay from Lake Michigan; these include Little Gull, Gravely, St. Martins, Summer and Poverty Islands. This management unit is entirely in 1836 Treaty waters, and contains a lake trout refuge. The refuge occupies nearly 5,000 square miles of the management unit and occupies the southern ½ of grids 313 and 314, grids 413, 414, 513-516, the northwest quarter of grid 517, grid 613, and the northern ½ of grid 614. It is illegal for recreational fishers to retain lake trout when fishing in the refuge area. Gill net fishing (both commercial and subsistence) is prohibited in the refuge, some commercial trap-net operations are permitted, however, the retention of lake trout is prohibited.

Recruitment of lake trout in the northern management unit of Lake Michigan is based almost entirely on stocking. In each of the last ten years, approximately 770,000 yearling lake trout have been stocked into northern Lake Michigan and approximately 87 percent of these fish are stocked into the northern refuge area. To more accurately estimate recruitment in the model, the number of fish stocked is adjusted to account for mortality and movement among the various regions in the lake. Over the last 10 years (1991-2000) the recruitment to age one has averaged 458,000 fish in northern Lake Michigan.

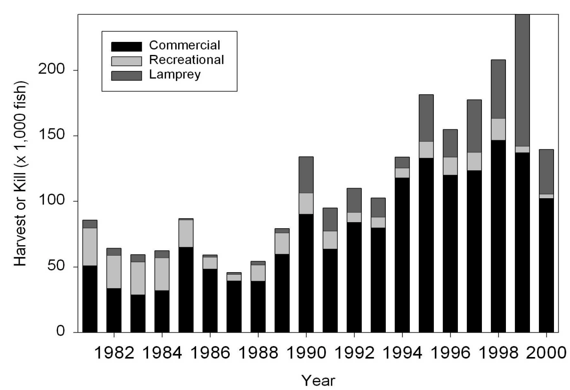

Figure 1. *Numbers of lake trout killed by fishing and by sea lamprey in the non-refuge waters of Lake Michigan Unit MM-123 from 1981 to 2000.*

The commercial fishery in northern Lake Michigan is comprised of both state and tribal commercial fisheries. State-licensed commercial fishermen are not permitted to harvest lake trout and therefore are not included in lake trout harvest allocations. The current tribal commercial fishery primarily targets lake whitefish, however, lake trout are sometimes targeted or kept as by-catch. Since 1981 commercial fishing has killed more harvestable lake trout (fish > 17in.) than other sources of mortality in northern Lake Michigan (Figure 1).

There are three types of tribal commercial fisheries, large-mesh gill net, small-mesh gill net, and trap net in the unit. The large-mesh gill-net fishery takes the majority of the yield. Tribal commercial yield increased from 411,000 lb in 1993 to 843,000 lb in 1999 before falling to 633,000 lb in 2000. Large-mesh gill-net effort in tribal fisheries remained consistent from 1993 to 1999, averaging 17 million feet and dropped significantly in 2000 to under eight million feet. The average number of fish harvested in northern Lake Michigan tribal fisheries from 1996 to 2000 was just over 126,000 (Figure 1). It is anticipated that major decreases in lake trout harvest in the northern management unit of Lake Michigan observed in 2000 will be observed in future years as a result of tribal gill-net fishers converting to trap nets as part of the Consent Decree.

The management of recreational fisheries for lake trout is the responsibility of the state of Michigan and fisheries are comprised of both charter and sport anglers. The mortality rate of lake trout resulting from recreational fishing in the northern management unit of Lake Michigan is significantly lower than rates associated with commercial fishing or sea lamprey predation (Figure 2). In 1991, the minimum size limit for sport fishing in the northern management unit of Lake Michigan was increased from 10 to 24 inches. A modest decline in recreational yield resulted because a substantial proportion of the stock was protected. In recent years, the estimated recreational yield of lake trout has declined further, by nearly 70 percent from 1998 (76,000 lb) to 2000 (22,000 lb). The numbers harvested declined similarly (Figure 1). This more recent decline is at least partly due to a decline in recreational fishing effort, as angler hours decreased nearly 49 percent, from 136,000 in 1998 to 70,000 in 2000.

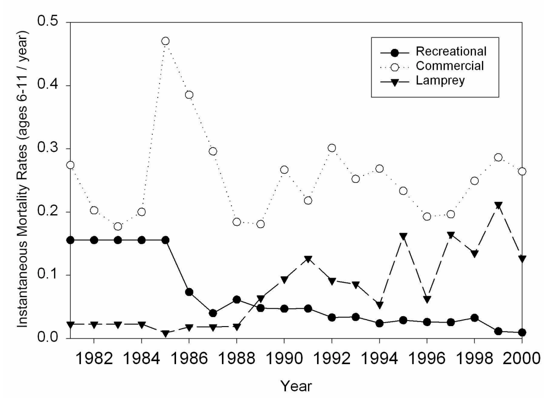

Figure 2. *Instantaneous mortality rates (from fishing and sea lamprey) of lake trout ages 6-11 in Lake Michigan Unit MM-123 in non-refuge waters (1981-2000).*

During 1989-2000, sea lamprey-induced mortality has been the second highest source of mortality for lake trout in northern Lake Michigan. In general, these mortality rates appear to be rising particularly over the last five years (Figure 2). The number of lake trout killed by sea lamprey has increased from an average of 4,600 over 1981-1985 to an average just over 48,000 during 1996-2000 (Figure 1). Fisheries managers blame an influx of sea lamprey from previously uncontrolled populations of lamprey from the St. Marys River in northern Lake Huron for the increasing lamprey mortality rates in northern Lake Michigan. In 1999, a sea lamprey control program was initiated on the St. Marys River. When recommending a yield limit for northern Lake Michigan for the year 2000, no adjustments were made for potential reductions in mortality caused by sea lamprey, as a result of the St. Marys River sea lamprey control effort. In the future, projections will be adjusted to account for any estimated reductions in sea lamprey populations.

In northern Lake Michigan lake trout generally are spawning and recruited into commercial and recreational fisheries by age 6 (Summary table). Biomass of lake trout had been increasing in northern Lake Michigan since 1987, but has decreased since 1997 (Figure 3). Spawning biomass shows a similar pattern with a less pronounced peak in 1997. The decline since 1997 is more pronounced when only considering fish outside the refuge. Total biomass of lake trout outside the refuge averaged 3.9 million lb during 1991-2000, rising from 1.5 million lb in 1987 to 5.1 million lb in 1997 and then declining to 3.5 million lb in 2000.

The spawning stock biomass produced per recruit (including the refuge population) during 1998-2000 is slightly above the target value indicating that mortality rates for the combined refuge/non-refuge population are not exceeding the 40% mortality target for this area.

The recommended yield limit for 1836 Treaty waters in 2001 is 35,000 pounds for the state recreational fishery and 486,000 pounds for the tribal commercial/subsistence fishery. These values reflect phase in requirements specified in the Consent Decree. When fully phased in, yield allocations in this management unit will allot 10% to the state and 90% to tribal fisheries, while meeting the 40% target mortality rate. In 2001, three options were considered: 1) the modeled allowable yield (36,000 lb state and 321,00 lb tribal); 2) the average of the yield from 1997 to 1999 less the reduction due to gill net conversions in the area (35,000 lb state and 486,000 lb tribal); or 3) tribal yield not less than 450,000 lb. Consistent with the Consent Decree specifications, option two was selected and approved by the TFC because it provided the highest tribal yield of lake trout. This specific phase-in option actually allows a temporary increase in mortality rates above the 40% target.

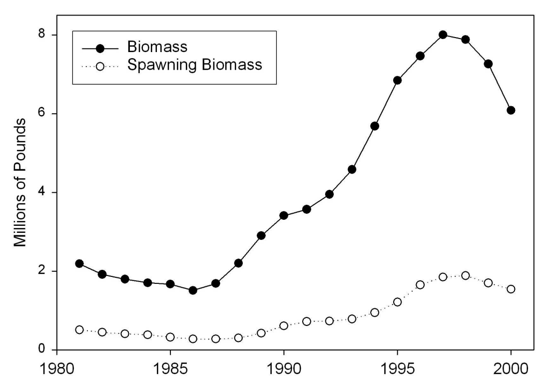

Figure 3. *SCAA estimated biomass (age-1 and older) and spawning biomass in MM-123, including refuge area.*

Summary Status – MM-123 lake trout	
Female maturity	
Length at first spawning	16.4 in
Age at first spawning	3 y
Length at 50% maturity	24.3 in
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	3.321 lb
Current SSBR combined w/ refuge	0.997 lb
SSBR at target mortality	0.970 lb
Spawning potential reduction	
At target mortality	0.292
Average yield per recruit	0.477 lb
Natural mortality (M)	0.233 y^{-1}
Fishing mortality	
Fully selected age	
Commercial fishery (1998-2000)	6 y
Fully selected age	
Sport fishery (1998-2000)	6 y
Commercial fishery F	
(average 1998-2000, ages 6-11)	0.267 y^{-1}
Sport fishery F	
(average 1998-2000, ages 6-11)	0.018 y^{-1}
Sea lamprey mortality (ML)	
(average ages 6-11, 1998-2000)	0.158 y^{-1}
Total mortality rate (Z)	
(average ages 6-11, 1998-2000)	0.676 y^{-1}
Recruitment (age-1)	458,000 fish
(1991-2000 average)	
Biomass (age 3+)	3,946,000 lb
(1991-2000 average)	
Spawning biomass	724,000 lb
(1991-2000 average)	
Recommended yield limit in 2001	521,000 lb

MM-4 (Grand Traverse Bay-Lake Michigan)

Prepared by Jory L. Jonas, James R. Bence, and Erik J. Olsen

Lake trout management unit MM-4 encompasses the Grand Traverse Bay region of Lake Michigan, and is the same as the MM-4 statistical district. There are two islands in this management unit, Bellow and Marion Islands, and a large peninsula bisects the southern half of the bay. For the most part water depths in the bay range up to 280 feet. However, waters on either side of the peninsula are much deeper, ranging up to 440 feet in the west arm and 640 feet in the east arm. This management unit is entirely in 1836 Treaty waters and there are no refuge areas. The total area of the unit is 255 square miles of which 168 square miles are less than 240 feet in depth. Based on estimates from historical commercial catch rates only a small amount of lake trout spawning habitat is located in this management unit. However, Grand Traverse Bay is one of the only areas of Lake Michigan where the recruitment of naturally reproduced lake trout has been documented. In the mid-1980s the frequency of unclipped fish in the bay increased significantly leading biologists to believe that rehabilitation efforts were succeeding. Unfortunately, in more recent evaluations few unclipped lake trout have been seen. This area constitutes an area of high use by both tribal and state interests.

The recruitment of lake trout in Grand Traverse Bay is based entirely on stocking. The U.S Fish and Wildlife Service is the primary agency responsible for stocking lake trout in Lake Michigan. In each of the last ten years, on average, 253,000 yearling lake trout have been stocked into Grand Traverse Bay. To more accurately estimate recruitment in the model, the number of fish stocked is adjusted to account for variations in mortality and for movement among the various regions in the lake. Over the last 10 years (1991-2000) the recruitment to age 1 has averaged 270,000 fish in the Grand Traverse management unit (Summary table).

From 1993 until 1997 more lake trout were killed by commercial fishing than by either sea lamprey or sport fishing (Figure 1) in this management unit. However, in during 1998-2000 the proportions killed by the three sources were similar. Commercial fishing mortality in Grand Traverse Bay peaked in 1994 at 0.53 y^{-1}, remained stable over

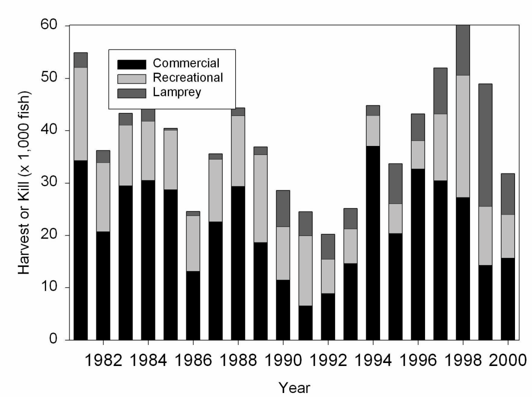

Figure 1. *Numbers of lake trout killed by fishing and by sea lamprey in the Grand Traverse Bay management unit of Lake Michigan from 1981 to 2000.*

the next several years (average of 0.24), declined in 1999 to 0.16 and rose to 0.21 in 2000 (Figure 2).

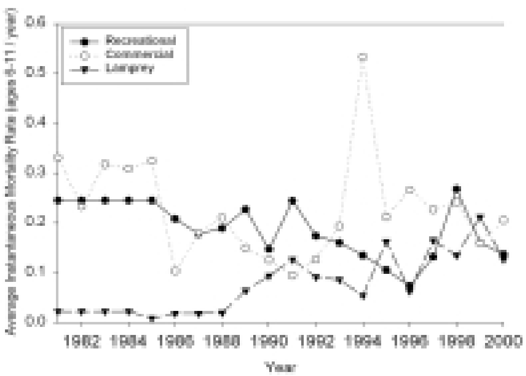

Figure 2. *Instantaneous mortality rates from fishing and sea lamprey of lake trout ages 6-11 in Lake Michigan Unit MM-4 (1981-2000.*

Only tribal fishermen commercially harvest fish in this management unit. There are three types of tribal commercial fisheries, large-mesh gill net, small-mesh gill net, and trap net. The large-mesh gill net fishery is responsible for the greatest number of harvested lake trout. The commercial harvest of lake trout in tribal large-mesh gill-net fisheries peaked in 1994 at nearly 37 ,000, declined to about 20,000 in 1995, averaged near 30,000 for the next three years and declined to an average of about 15,000 in the last two years. The estimated yield of lake trout captured in tribal commercial fisheries (all gear types) averaged 176,000 lb from 1996 to 1998 and has declined to an average of 95,000 lb during 1999 and 2000. Large-mesh gill-net effort in tribal fisheries was highest in 1994 at nearly 5 million feet but has varied near a lower average of about 2 million feet during 1995-2000. It is expected that major decreases in the commercial harvest of lake trout in the Grand Traverse Bay management unit will be observed in future years as a result of converting the regions largest gill-net fishers to trap-net operations.

The management of recreational fisheries for lake trout is the responsibility of the state of Michigan and fisheries are comprised of both charter and sport anglers. The sportfishing harvest regulations in the Grand Traverse Bay management unit have changed significantly over the last 10 years, affecting recreational fishing mortality rates and harvest levels. From 1992 to 1996 the minimum size limit for lake trout harvest was increased from 10 to 24 inches. In 1996 the season for harvesting lake trout was lengthened, so that it extended from January 1 through September 30 in contrast with the previous season of May 1 through Labor Day. Mid-way through the year in 1997 the minimum size was decreased to 20 inches and has remained so through the year 2000. The mortality rates of lake trout resulting from recreational fishing have steadily declined from 1992 (rate of 0.17) to 1996 (rate of 0.07). After 1996 mortality rates increased to a high of 0.27 in 1998 and for unknown reasons have declined to average 0.15 in 1999 and 2000. The estimated recreational yield of lake trout in Grand Traverse Bay had been consistent during the years 1992-1996 averaging 38,000 lb. However, from 1996 to 1998 the recreational yield of lake trout increased dramatically to 152,000 lb, and in the recent two years (1999 and 2000) yield has declined, falling to 56,000 lb in 2000. The numbers of lake trout harvested were also similar from 1992 to 1996 averaging about 6,000 fish. A dramatic increase was observed from 1996 to 1998 when 23,000 fish were harvested. More recently the harvest of lake trout has declined, falling to an estimated 8,000 fish in 2000. Estimated recreational fishing effort declined steadily from 340,000 angler hours in 1991 to 113,000 angler hours in 1996. From 1996 to 1998 an increase of nearly 70 percent was observed, as estimated effort levels rose to 388,000 angler hours by 1998. As we had observed for harvest and biomass estimates, angler effort has declined in the recent two years (1999 and 2000), falling to 199,000 angler hours in 2000.

From 1981 to 1988 sea lamprey-induced mortality was the lowest source of mortality in the Grand Traverse Bay management unit with instantaneous rates averaging 0.02. Rates then gradually increased to 0.13 by 1991, after which they were more variable and appeared to be generally increasing. The highest lamprey mortality rate was observed in 1999 at 0.21. In recent years (1998-2000), the mortality rates from all three sources (commercial, recreational and lamprey) are similar. The recent three-year (1998-2000) average mortality rate for lake trout age 6-11 is 0.16. Omitting the extreme case of 1999, the average number of lake trout killed by sea lamprey during 1996-2000 has been about 7,800 fish. In 1999 lamprey are estimated to have killed over 23,000 lake trout from the management unit. Fisheries managers often blame the potential influx of sea lamprey from previously uncontrolled populations in the St. Marys River in northern Lake Huron for the increasing lamprey mortality rates in northern Lake Michigan. It is possible that this is the case for Grand Traverse Bay as well. In 1999, the U.S. Fish and Wildlife Service initiated lamprey control measures on the St. Marys River. It is also possible that in future years the benefits of lamprey control in the St. Marys River will be realized in terms of decreased lamprey mortality rates in the Grand Traverse Bay region of Lake Michigan.

In general in the Grand Traverse Bay management unit, lake trout are recruited into commercial fisheries by age 6 and recreational fisheries by age 7. Lake trout in this management unit first spawn at age 3 and 50 percent or more are spawning by age 6. The total biomass of lake trout has averaged 1.3 million pounds during the last 10 years (1991-2000). Biomass of lake trout rose from a low of 0.9 million lb in 1991 to a high of 1.6 million pounds in 1996 and has since declined to 1.2 million pounds in 2000. The biomass of spawning lake trout in Grand Traverse Bay has been declining since 1997. In 1998, it was estimated that the spawning stock biomass was 225,000 lb and by the year 2000 the estimate had decreased to 150,000 lb. The biomass of spawning lake trout in the management unit has averaged 153,000 lb during the last ten years (1991-2000).

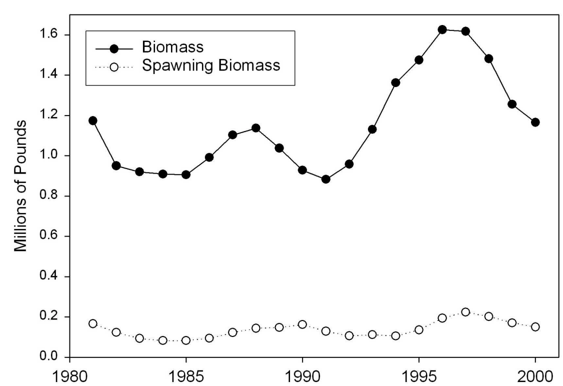

Figure 3. *SCAA estimated biomass (age-1 and older) and spawning biomass in Lake Michigan Unit MM-4.*

The spawning stock biomass produced per recruit is below the target value indicating that the mortality rate is too high in Grand Traverse Bay.

Grand Traverse Bay represents an area where unique phase in requirements were considered in establishing yield limits. From 2001 to 2005 commercial yield limits are to be set in Grand Traverse Bay based on the mean yield and effort from 1997 to 1999. For commercial fishing, the yield and effort limit is determined as the mean minus the conversion of gill-net effort to trap nets. Recreational yield limits are set at the mean for the previous three years and are to be adjusted for regulation changes. After 2005 yield and effort limits will be set to meet the target mortality rate for this area of 45%, with a 45 percent allocation to the state of Michigan and a 55 percent allocation to tribal fisheries.

The recommended yield limit for the year 2001 in the Grand Traverse Bay management unit is 127,000 lb of which 57,000 lb is allocated to the state recreational fishery and 70,000 lb to the tribal commercial/subsistence fishery. This does not follow the phase-in methods described above, but rather represents the final, after phase-in, allocation indicated by the Consent Decree of 45% to the state and 55% to the tribe. This compromise was reached by the TFC in an attempt to address concerns expressed by the Grand Traverse Band that the 2001 tribal harvest limit was considerably below harvest levels predicted during negotiations and would represent a severe hardship for their fishers. Under the phase-in method, the 2001 allocation would have been 73,000 lb for the state and 68,000 lb for the tribes.

Summary Status – MM-4 lake trout	
Female maturity	
Length at first spawning	15.4 in
Age at first spawning	3 y
Length at 50% maturity	24.9 in
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	1.516 lb
Current SSBR combined w/ refuge	0.316 lb
SSBR at target mortality	0.415 lb
Spawning potential reduction	
At target mortality	0.274
Average yield per recruit	0.313 lb
Natural mortality (M)	0.268 y^{-1}
Fishing mortality	
Fully selected age	
Commercial fishery (1998-2000)	6 y
Fully selected age	
Sport fishery (1998-2000)	7 y
Commercial fishery F	
(average 1998-2000, ages 6-11)	0.202 y^{-1}
Sport fishery F	
(average 1998-2000, ages 6-11)	0.189 y^{-1}
Sea lamprey mortality (ML)	
(average ages 6-11, 1998-2000)	0.158 y^{-1}
Total mortality rate (Z)	
(average ages 6-11, 1998-2000)	0.818 y^{-1}
Recruitment (age-1)	270,400 fish
(1991-2000 average)	
Biomass (age 3+)	1,296,000 lb
(1991-2000 average)	
Spawning biomass	153,000 lb
(1991-2000 average)	
Recommended yield limit in 2001	127,000 lb

MM-5 (Lake Michigan-Leelanau Peninsula to Arcadia)

Prepared by Jory L. Jonas, James R. Bence, and Erik J. Olsen

Lake trout management unit MM-5 is located in eastern central Lake Michigan and corresponds to the MM-5 statistical district. This area constitutes an area of high use by both tribal and state interests. The unit covers 2,100 square miles and encompasses Michigan's waters of Lake Michigan from Arcadia north to the tip of the Leelanau Peninsula, out to the state line bisecting the middle of the lake. There are two islands in this management unit, the North and South Manitou Islands. Some of the deepest waters and largest drop-offs in Lake Michigan occur in MM-5. Depths range from 0 up to 825 feet and for the most part water depths are greater than 400 feet, with only 440 square miles at depths less than 240 feet. This management unit is entirely in 1836 Treaty waters and there are no refuge areas. Only a small amount of lake trout spawning habitat is located in this management unit, most of which is in the nearshore zone and around the North and South Manitou Islands.

The recruitment of harvestable lake trout in the MM-5 is based entirely on stocking. The U.S Fish and Wildlife Service is the primary agency responsible for stocking lake trout in Lake Michigan. Over last ten years, an average of 233,000 yearling lake trout have been stocked into the MM-5 management unit annually. To more accurately estimate recruitment in the model, the number of fish stocked is adjusted to account for variations in mortality and for movement among the various regions in the lake. Over the last 10 years (1991-2000) the recruitment to age 1 has averaged 250,000 fish in MM-5.

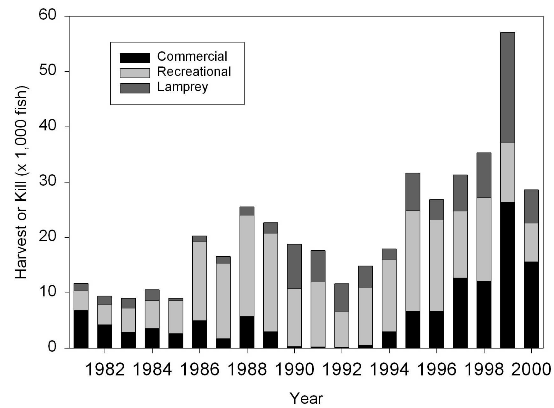

***Figure 1**. Numbers of lake trout killed by fishing and by sea lamprey in Lake Michigan Unit MM-5 from 1981 to 2000.*

Since 1993, mortality from commercial fishing has been increasing in MM-5, and in recent years, commercial fishing is the source of mortality that has killed the most harvestable size lake trout (Figure 1). Commercial fishing mortality rate peaked at a rate of 0.29 (averaged over ages 6-11) in 1999 (Figure 2). Although both state and tribal commercial fishermen harvest fish in this management unit, state-licensed commercial fisheries are trap-net and small-mesh gill net operations targeting lake whitefish and bloater chubs, respectively. State licensed fishermen are not permitted to harvest lake trout, and as a result, are not included in lake trout harvest allocations. There are three types of tribal commercial fisheries, large-mesh gill net, small-mesh gill net, and trap net. The large-mesh gill net fishery is responsible for the greatest number of harvested lake trout. Since 1992, the harvest of lake trout in tribal large-mesh gill-net fisheries has been increasing. The estimated tribal commercial yield of lake trout has ranged from 1,600 lb in 1992 to a high of 152,000 lb in 1999. In 2000 the yield declined to 87,000 lb. The number of fish harvested over the last five years (1996-2000) was variable, and averaged 14,000 fish. Large-mesh gill-net effort in tribal fisheries increased incrementally after 1993 from a low of 36,000 feet in 1993, to a high of 1.17 million feet in 1999. As we observed for estimated yield, effort also declined somewhat, falling to 850,000 feet in the year 2000. It is expected that major decreases in the commercial harvest of lake trout in management unit MM-5 of Lake Michigan will be observed in future years as the results of converting the regions largest gill-net fishers to trap-net operations are realized.

The recreational fisheries for lake trout are comprised of both charter and sport anglers. Until recently recreational fishing mortality exceeded sea lamprey and commercial fishing mortality in MM-5. However, recreational fishing mortality rates on lake trout (averaged over ages 6-11) have dropped significantly from the high of 0.23 observed in 1995 to an average over the most recent three years (1998-2000) of 0.14. The estimated recreational yield of lake trout has been variable and high over the 13-year period between 1986 and 1998 averaging 82,000 lb. In recent years a steady decline in this yield has been observed, dropping from 89,000 lb in 1998 to 42,000 lb in 2000. The estimated numbers of lake trout harvested by the recreational fishery have also declined by nearly 46 percent from 1998 (15,000) to 2000 (6,900). Recreational fishing effort has declined dramatically from an estimated high of 612,000 angler hours in 1995 to 295,000 angler hours in 2000. The sportfishing harvest regulations in the MM-5 management unit of Lake Michigan have historically allowed for the take of 10-inch lake trout, however, in the year 2001 the minimum harvest limit was changed to 22 inches. As a result, a reduction in recreational harvest in the MM-5 management unit of Lake Michigan should be realized in future years.

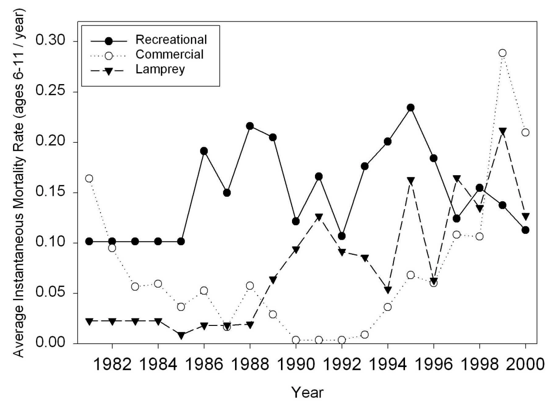

Figure 2. *Instantaneous mortality rates of lake trout ages 6-11 in Lake Michigan Unit MM-5 (1981-2000) from sea lamprey and fishing.*

Sea lamprey-induced mortality has increased in recent years in MM-5. From 1981 to 1988 sea lamprey mortality was less than either recreational or commercial mortality. From 1988 to 1991 sea lamprey mortality rates have steadily increased and from 1991 to 2000 mortality from sea lamprey has remained relatively high and is much more variable across years (Figure 2). Peak sea lamprey mortality rates in the management unit were observed in 1999 at 0.21 (Figure 2). The recent three-year (1998-2000) average sea lamprey-induced lake trout mortality (averaged over ages 6-11) is 0.16. The average number of deaths of lake trout from sea lamprey during 1996 to 2000 (omitting the extreme case of 1999) has been 6,100 fish (Figure 1). In 1999 lamprey are estimated to have killed nearly 20,000 lake trout from the management unit. Fisheries managers often blame the potential influx of sea lamprey from previously uncontrolled populations from the St. Marys River in northern Lake Huron for the increasing sea lamprey mortality rates in northern Lake Michigan. It is possible that this is the case for management unit MM-5 as well. In 1999, the U.S. Fish and Wildlife Service initiated lamprey control measures on the St. Marys River. It is possible that in future years the benefits of sea lamprey control in the St. Marys River will be realized in terms of decreased mortality rates in MM-5.

In general, lake trout in MM-5 are both spawning and recruited into commercial and recreational fisheries by age 6. The total biomass rose to a peak in 1988, declined in the late 1980s and early 1990s and then rose to its highest value in 1997, before declining to levels below 1 million pounds in 2000 (Figure 3). The biomass of spawners in the MM-5 showed a similar temporal pattern with peaks lagging those of total biomass by 1-2 years. However, the 1990 peak was higher than the 1998 peak for spawning biomass.

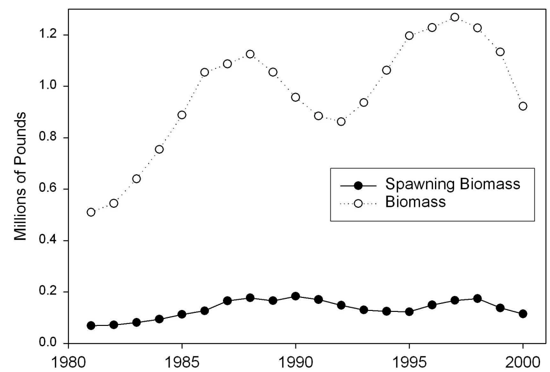

Figure 3. *SCAA estimated biomass (age-1 and older) and spawning biomass in Lake Michigan Unit MM-5.*

The spawning stock biomass produced per recruit is below the target value indicating that the mortality rate is too high in MM-5. The recommended yield limit for the year 2001 in Unit MM-5 is 53,000 pounds, which was set to match the target mortality rate of 45%. Of this yield, 32,000 pounds are allocated to the state recreational fishery and 21,000 pounds to the tribal commercial and subsistence fishery based on the Consent Decree allocation agreement of 60 percent to the state of Michigan and 40 percent to tribal fisheries.

Summary Status – MM-5 lake trout	
Female maturity	
Length at first spawning	15.4 in
Age at first spawning	3 y
Length at 50% maturity	25.5 in
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	0.953 lb
Current SSBR	0.229 lb
SSBR at target mortality	0.317 lb
Spawning potential reduction	
At target mortality	0.333
Average yield per recruit	0.217 lb
Natural mortality (M)	0.304 y^{-1}
Fishing mortality	
Fully selected age	
Commercial fishery (1998-2000)	6 y
Fully selected age	
Sport fishery (1998-2000)	6 y
Commercial fishery F	
(average 1998-2000, ages 6-11)	0.201 y^{-1}
Sport fishery F	
(average 1998-2000, ages 6-11)	0.135 y^{-1}
Sea lamprey mortality (ML)	
(average ages 6-11, 1998-2000)	0.158 y^{-1}
Total mortality rate (Z)	
(average ages 6-11, 1998-2000)	0.799 y^{-1}
Recruitment (age-1)	250,000 fish
(1991-2000 average)	
Biomass (age 3+)	486,000 lb
(1991-2000 average)	
Spawning biomass	65,000 lb
(1991-2000 average)	
Recommended yield limit in 2001	53,000 lb

MM-67 (Lake Michigan-Southern Treaty Waters)

Prepared by Jory L. Jonas, James R. Bence, and Archie W. Martell Jr.

Lake trout management unit MM-67 is located in eastern central Lake Michigan, and is made up of statistical districts MM-6 and MM-7. The area covers Michigan's waters of Lake Michigan from Arcadia to Holland, out to the state line bisecting the middle of the lake for a total of 4,460 square miles, of which 930 square miles are less than 240 feet in depth. The northern section of this region (MM-6) ranges in depth from 0 up to 900 feet and is characterized by greater slope than the southern section (MM-7). For the most part water depths in MM-7 are less than 400 feet. There are no islands or structures in this management unit, and there is little lake trout spawning habitat with the exception of offshore deepwater spawning reefs located within the mid-lake refuge. Stocked lake trout almost certainly attempt to spawn in the nearshore zones. However, the likelihood of successful recruitment is negligible. This management unit is not entirely comprised of 1836 Treaty waters, the northern section (MM-6) is entirely treaty ceded territory while only the northern two-thirds of the southern section (MM-7) is within treaty territory. Thus 690 square miles within the unit are outside 1836 Treaty waters. A line running parallel to the northern side of the Grand River (located approximately ¾ of the way through grids in the 1900 series) to the state line in the middle of the lake delineates the boundary of treaty territories in this zone. This management unit contains a portion of a deepwater mid-lake lake trout refuge, which makes up 850 square miles of the unit (grids 1606, 1607, 1706, 1707, 1806, 1807, 1906 and 1907). It is illegal for recreational fishers to retain lake trout when fishing in the refuge area. Gill net fishing (both commercial and subsistence) are prohibited in the refuge. Some state-licensed commercial trap-net operations are permitted, however, the retention of lake trout is prohibited. As of the year 2000 there was no tribal commercial fishing effort in this management unit.

The recruitment of lake trout in MM-67 is based almost entirely on stocking. During the past ten years, an average of 151,000 yearling lake trout have been stocked into non-refuge waters, while an additional 417,000 fish were stocked into the mid-lake refuge area much of which is in Wisconsin's waters. To more accurately estimate recruitment in the model, the number of fish stocked is adjusted to account for varying mortality and for movement among the various regions in the lake. Over the last 10 years (1991-2000) the recruitment to age 1 has averaged 372,000 fish in this management unit.

Since 1986 commercial fishing has killed many fewer lake trout of harvestable size in MM-67 than either recreational fishing or sea lamprey (Figure 1). State-licensed commercial fisheries primarily target lake whitefish and chubs, and they are not permitted to harvest lake trout. As a result, state commercial fishermen are not included in lake trout harvest allocations. The estimated yield in state commercial fisheries has ranged from a high of 160,400 lb in 1983 to a low of

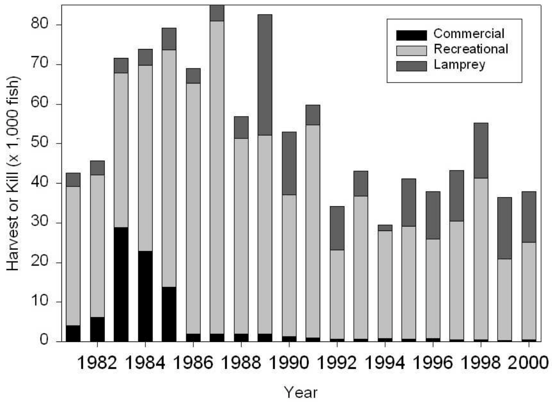

Figure 1. *Numbers of lake trout killed by fishing and by sea lamprey in Lake Michigan Unit MM-67 (non-refuge waters) from 1981 to 2000.*

2,300 lb in 1999. On average commercial fisheries harvested less than 500 fish from this management unit during 1996-2000. As a result of stipulations of the Consent Decree, this area may experience greater commercial fishing effort from tribal interests in the future.

The state recreational fisheries for lake trout are comprised of both charter and sport anglers. Recreational fishing mortality is higher than either commercial fishing mortality or mortality due to sea lamprey (Figure 2). However, in recent years observed recreational fishing mortality rates have dropped significantly, becoming more similar to those observed for sea lamprey. The estimated recreational yield of lake trout in recreational fisheries peaked in 1987 at 483,000 lb and declined to 166,000 lb in 2000. The estimated numbers of lake trout harvested have also declined by nearly 30 percent over the years, from a peak of 79,000 fish in 1987 to 25,000 fish in 2000 (Figure 1). Fluctuations in effort mirror harvest fluctuations in this management unit, and also declined by nearly 30 percent in the last thirteen years. The minimum size limit for lake trout in the management unit is 10 inches, the bag limit is two fish per day, and the recreational fishing season extends from January 1 until Labor Day. The size and bag limits have not changed since 1981. However, the fishing season has changed twice, once in 1984 where the season was restricted from the entire year to May 1 through August 15th, and again in 1989 when the season was extended through Labor Day.

Sea lamprey-induced mortality is lower in southern treaty waters of Lake Michigan, when compared with rates observed in the northern units. These rates ranged from 0.03 to 0.07 (Figure 2). In the last five years (1996-2000), the average number of lake trout killed by lamprey averaged 13,000 fish (Figure 1).

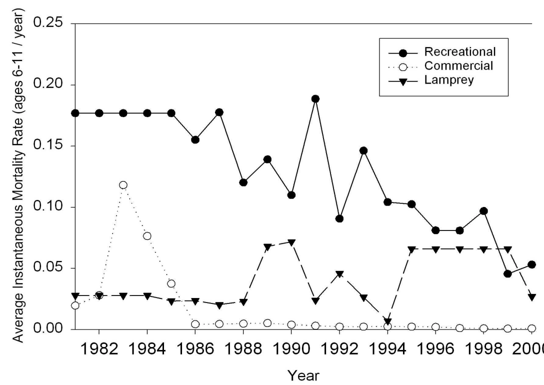

Figure 2. *Instantaneous mortality rates of lake trout ages 6-11 in non-refuge waters of Unit MM-67 of Lake Michigan (1981-2000) from sea lamprey and fishing.*

In general in MM-67 lake trout are spawning and recruited into commercial and recreational fisheries by age 6. The total biomass of lake trout averaged over

3 million lb during 1991-2000, and reached its highest level in the assessment period (1981-2000) in 2000 (Figure 3), increasing from 1.8 million lb in 1981. Spawners make up a relatively high proportion of the total biomass in this unit forms (Figure 3), averaging 0.9 million lb during 1991-2000. Spawning biomass of lake trout in MM-67 has followed a similar temporal pattern to that observed for total biomass.

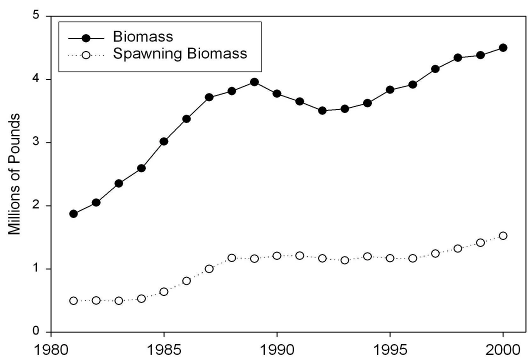

Figure 3. *SCAA estimated biomass (age-1 and older) and spawning biomass in Lake Michigan Unit MM-67 for refuge and non-refuge waters combined*

The spawning stock biomass produced per recruit is significantly above the target value indicating that target mortality rates have been achieved in MM-67 (Summary table).

The recommended yield limit for the year 2000 in MM-67 is 920,000 lb. Of this, 828,000 pounds are allocated to the state recreational fishery and 92,000 pounds to the tribal commercial and subsistence fishery. The yield limit and allocations in this management unit are set to achieve a total mortality rate target of 40% and establish a 90 percent allocation to the state and a 10 percent allocation to tribal fisheries.

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Summary Status – MM-67 lake trout	
Female maturity	
Length at first spawning	15.5 in
Age at first spawning	3 y
Length at 50% maturity	24.0 in
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	3.233 lb
Current SSBR	1.658 lb
SSBR at target mortality	0.654 lb
Spawning potential reduction	
At target mortality	0.202
Average yield per recruit	0.232 lb
Natural mortality (M)	0.190 y^{-1}
Fishing mortality	
Fully selected age	
Commercial fishery (1998-2000)	6 y
Fully selected age	
Sport fishery (1998-2000)	6 y
Commercial fishery F	
(average 1998-2000, ages 6-11)	0.001 y^{-1}
Sport fishery F	
(average 1998-2000, ages 6-11)	0.065 y^{-1}
Sea lamprey mortality (ML)	
(average ages 6-11, 1998-2000)	0.053 y^{-1}
Total mortality rate (Z)	
(average ages 6-11, 1998-2000)	0.309 y^{-1}
Recruitment (age-1)	372,000 fish
(1991-2000 average)	
Biomass (age 3+)	3,064,000 lb
(1991-2000 average)	
Spawning biomass	918,000 lb
(1991-2000 average)	
Recommended yield limit in 2001	920,000 lb

STATUS OF LAKE WHITEFISH POPULATIONS

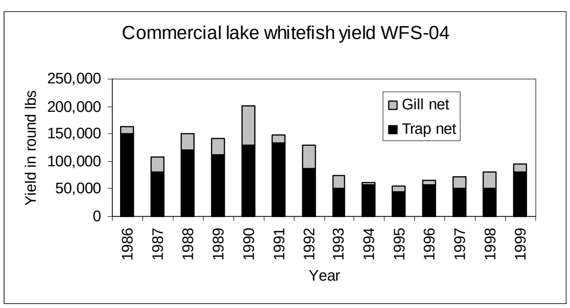
Lake Superior

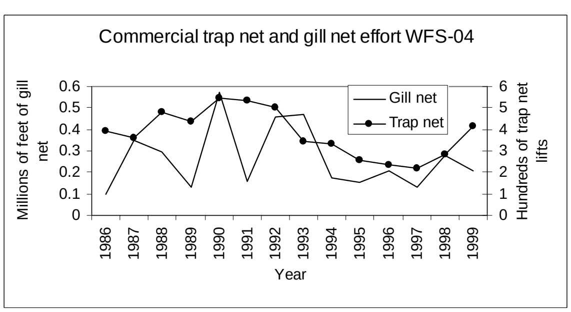
WFS-04 (Big Bay, Marquette)

Prepared by Philip J. Schneeberger

Lake whitefish unit WFS-04 (1,201,498 surface acres) is located in Lake Superior roughly between Big Bay and Laughing Fish Point east of Marquette. Fishable grids in this unit include 1326-1327, 1428-1429, and 1529-1531. Near shoreline features of this zone include many points, bays, islands, and in-flowing rivers. Habitat suitable for lake whitefish growth and reproduction is associated with many of these features.

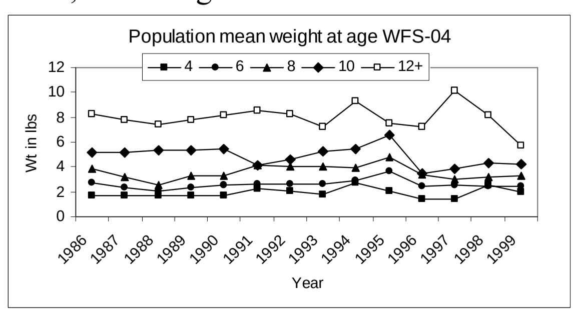
This unit historically has been treated as a single management area though it certainly contains several reproductively isolated stocks. It contains waters both within and outside the 1836 Treaty waters, but more than 90% of trap-net effort and yield are from waters west of the treaty line.





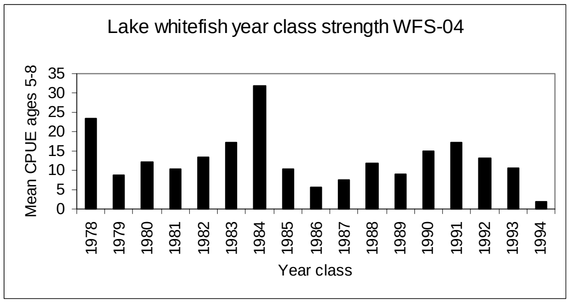
Yield of lake whitefish for both gill nets and trap nets has been relatively stable since 1995 at levels lower than recorded during the late 1980s and early 1990s. Yield averaged 84,000 lb for trap nets and 24,000 lb for gill nets between 1986 and 1999. On average, trap nets accounted for 78% of the lake whitefish yield from WFS-04.

Fishing effort declined for both gear types during the 1990s, though trap-net effort turned upward toward the end of the period. Peak effort occurred in 1990 with 571,000 ft of gill net and 546 trap-net lifts. Lowest effort occurred in 1997 for trap nets (217 lifts) and 1986 for gill nets (99,000 ft). Average effort between 1986 and 1999 was 381 trap lifts and 264,000 ft of gill net.



Fish most prominent in the WFS-04 fishery range from 19 to 23 inches, but 10% measure 26 inches or greater. Most fish harvested (83%) are from age 5 to age 9. Mean length, weight, and age of commercially caught whitefish have varied considerably without trend. Whitefish size-at-age has decreased over the 1986-99 period.

The most successful year class in the last 20 years occurred in 1984. Strength of subsequent year classes has been unremarkable but fairly consistent. Model outputs indicated that from 1990 through 1999, the average recruitment of age-4 lake whitefish in WFS-04 averaged 201,000 fish.



During 1990-99, fishable biomass (fish aged 4 and older) averaged 788,000 lb. Following a gradual decline from 1990 to 1993, fishable biomass has increased substantially, peaking at 1.15 million lb in 1999.

Average spawning stock biomass during 1990-99 was 532,000 lb or about 65% of the average fishable biomass. Spawning stock biomass was lowest in 1993 at 401,000 lb and highest in 1999 at 774,000 lb.

Fishing mortality (F) imposed during 1997-99 was 0.12 y^{-1} for trap nets and 0.04 y^{-1} for gill nets. Total instantaneous mortality rate (Z) was 0.38 y^{-1} during this period.

The WFS-04 lake whitefish stock can support additional exploitation. The 2001 quota was set at 440,000 lb. Under this level of exploitation, the maximum target mortality target rate would not be exceeded. To achieve the mandated split between tribal and state-licensed fishers (state is allocated 10% of the quota or 25,000 lb, whichever is less), gill-net effort by tribal fishers would increase 11 fold and trap-net effort by state fishers would decrease to a third of recent levels. This would result in a yield of 415,000 lb for gill nets and 25,000 lb for trap nets.

Summary Status – WFS-04 lake whitefish	
Female maturity	
Size at first spawning	1.61 lb
Age at first spawning	4 y
Size at 50% maturity	1.98 lb
Age at 50% maturity	5 y
Spawning stock biomass per recruit	
Base SSBR	2.04 lb
Current SSBR	0.90 lb
SSBR at target mortality	0.48 lb
Spawning potential reduction	
At target mortality	0.23
Average yield per recruit	0.50 lb
Natural mortality (M)	0.22 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	11 y
Fully selected age to trap nets	9 y
Average gill net ages 4+	0.04 y^{-1}
Average trap net ages 4+	0.12 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0 y^{-1}
Total mortality rate (Z)	
Average 4+ 1997-1999	0.38 y^{-1}
Average 4+ 1999	0.39 y^{-1}
Average 4+ 2001	0.73 y^{-1}
Recruitment (age-4) (1990-1999 average)	201,000 fish
Biomass (age 4+) (1990-1999 average)	788,000 lb
Spawning biomass (1990-1999 average)	532,000 lb
Recommended yield limit in 2001	440,000 lb

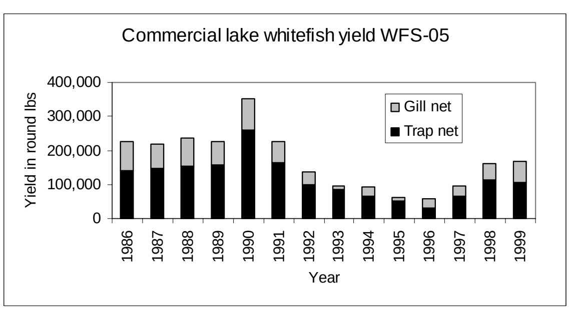
WFS-05 (Munising)

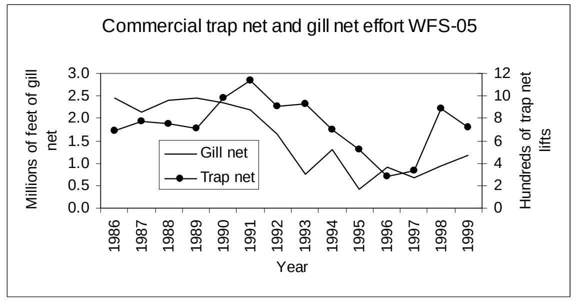
Prepared by Philip J. Schneeberger

The WFS-05 lake whitefish management unit extends approximately from Laughing Point to Au Sable Point in Lake Superior. Surface area is 1,845,495 acres. Several bays (Shelter Bay, Au Train Bay, South Bay, and Trout Bay) and islands (Au Train Island, Wood Island, Williams Island, and Grand Island) are prominent in this area, providing substrate and depth contours suitable for lake whitefish habitat and spawning. Different whitefish stocks exist within this unit, including a smaller, slower-growing stock identified in Munising (South) Bay.

Lake whitefish are harvested mostly by trap nets in WFS-05, though 30% of the total yield was taken by gill nets between 1986 and 1999. Average yield during 1986-99 was 117,000 lb for trap nets and 50,000 lb for gill nets. Yield peaked at 354,000 lb in 1990 and subsequently declined through 1995, then increased through 1999.

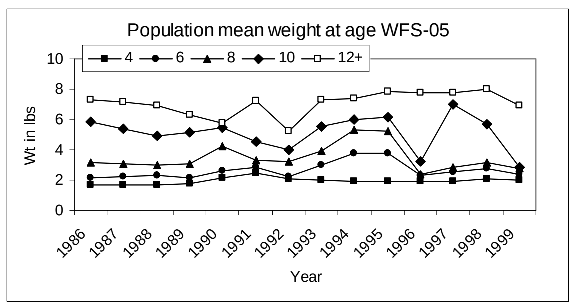
Fishing effort roughly paralleled yield trends. Gill-net effort peaked in 1989, fluctuated downward through 1995, then increased. Gill-net effort ranged from 428,000 ft to 2.5 million ft and averaged 1.6 million ft during 1986-99. Trap-net effort was highest in 1991, fell through 1996, then increased again.



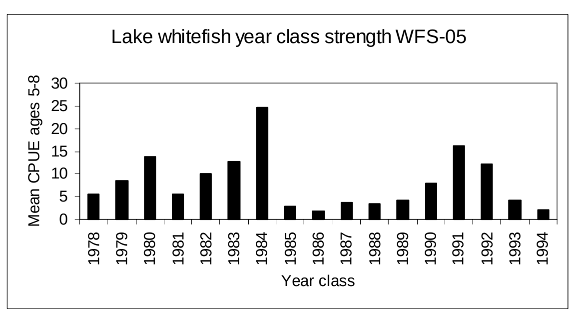


Effort by trap nets ranged from 284 to 1,139 lifts and averaged 737 lifts per year.

Most (94%) of the lake whitefish harvested from WFS-05 are 18 inches or greater, and 9% measure 26 inches or greater. Fish aged 5 to 9 are most prominent in catches, but fish age 12 or older are also well represented. Mean length, weight, and age of commercially caught whitefish have varied without trend.



Following a strong year class produced in 1984, year-class strength



was relatively low through 1990, then was moderate in 1991 and 1992. The stock assessment model for WFS-05 indicated that recruitment of age-4 whitefish averaged 161,000 fish for 1990-99. Number of recruits was lowest at the beginning of the period, peaked in 1995, and declined since then.

The fishable biomass of lake whitefish age 4 and older was an average of 1.8 million lb for 1990-99 according to model outputs. Available fishable biomass was lowest at the start of 1992 (928,000 lb) and highest in 1999 (2.9 million lb).

WFS-05 had an average spawning stock biomass of 1.2 million lb during 1990-99. On average, spawning stock biomass was 68% of the fishable biomass. Spawning stock biomass followed the same trend as fishable biomass, decreasing from the mid-1980s to the mid-1990s, then increasing through 1998.

Fishing mortality (F) was low from both gill nets and trap nets. During 1997-99, mortality imposed by fishing was 0.02 y^{-1} for gill nets and 0.08 y^{-1} for trap nets. Total instantaneous mortality rate (Z) was 0.33 y^{-1}, well below the target maximum.

Yield for 2001 that would allow the target mortality rate to be met was 487,000 lb. Reaching this level of harvest while maintaining the mandated split between tribal and state-licensed harvest (state is allocated 16% of the quota or 130,000 lb, whichever is less) would require trap-net effort to be reduced to 80% and gill-net effort to be increased 13 fold from the 1997 to 1999 average.

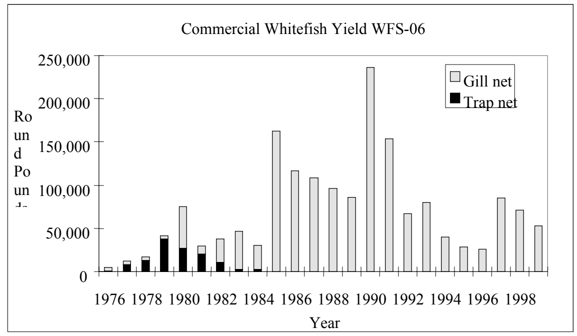
Summary Status – WFS-05 lake whitefish	
Female maturity	
Size at first spawning	2.01 lb
Age at first spawning	4 y
Size at 50% maturity	2.33 lb
Age at 50% maturity	5 y
Spawning stock biomass per recruit	
Base SSBR	1.80 lb
Current SSBR	0.95 lb
SSBR at target mortality	0.39 lb
Spawning potential reduction	
At target mortality	0.23
Average yield per recruit	0.35 lb
Natural mortality (M)	0.23 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	7 y
Fully selected age to trap nets	10 y
Average gill net ages 4+	0.02 y^{-1}
Average trap net ages 4+	0.08 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0 y^{-1}
Total mortality rate (Z)	
Average 4+ 1997-1999	0.33 y^{-1}
Average 4+ 1999	0.34 y^{-1}
Average 4+ 2001	0.59 y^{-1}
Recruitment (age-4) (1990-1999 average)	161,000 fish
Biomass (age 4+) (1990-1999 average)	1,780,000 lb
Spawning biomass (1990-1999 average)	1,187,000 lb
Recommended yield limit in 2001	487,000 lb

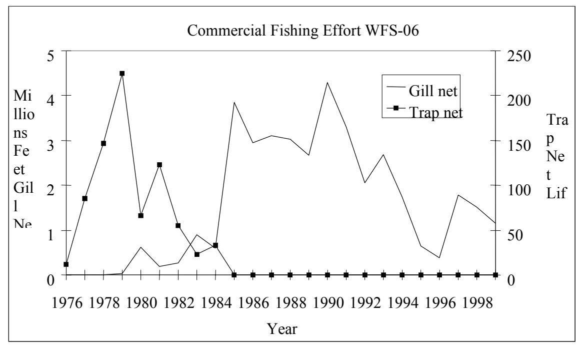
WFS-06 (Grand Marais Stock)

Prepared by Mark P. Ebener

Management unit WFS-06 is located in the center of the 1836 Treaty waters of Lake Superior. The unit is part of the open water of Lake Superior and contains no islands or bays. WFS-06 contains a small, relatively shallow water area <120 ft. deep that extends 3-4 miles into the lake from the shoreline along nearly the entire length of the management unit. The exception is off Au Sable Point, where the 120 ft. contour makes a sharp perpendicular turn towards shore. Depth of water increases abruptly to 200-500 ft. after the 120 ft. contour. Several shallow water shoals such as Southwest and Southeast Bank are located along the very northern boundary of WFS-06, but these are lake trout habitat, not whitefish habitat. The majority of the unit is deeper than 400 ft. and the deepest part of WFS-06 is 908 ft. There are 18 statistical grids that make up WFS-06, but of the total 950,000 acres in the unit, there is only 88,600 surface acres of waters <240 ft. deep.

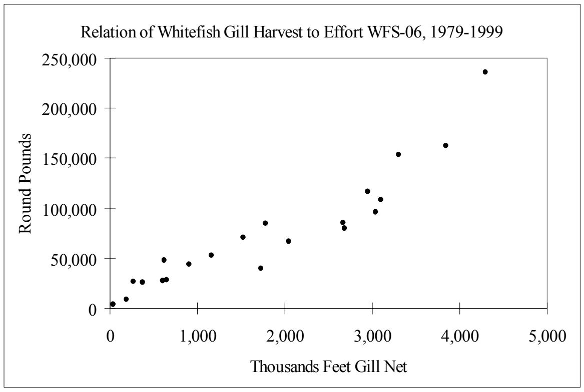
There is little habitat for whitefish reproduction in WFS-06. The entire shoreline of WFS-06 is relatively straight and is composed of sand with lesser amounts of small-size gravel and scattered cobble that are found only on the immediate shoreline. There are no rock reefs to support a large concentration of spawning. It is likely that many of the whitefish that inhabit WFS-06 spawn elsewhere. For example, spawning whitefish tagged and released in lower WFS-07 during 1981-1983 where regularly captured in WFS-06 and WFS-05 during the spring and summer of 1982-1990.





WFS-06 has been an exclusive commercial fishing zone for tribal fishermen since 1985. Because the unit is so exposed to the open water of Lake Superior and because access to the unit is limited to the Grand Marais area, only large-boat gill-net fisheries typically fish here. A state-licensed trap-net fishery did operate in the unit prior to 1985, but the fishery never put forth much effort or caught many fish.

The commercial yield of whitefish from WFS-06 averaged only 71,000 lb during 1976-1999. The peak yield was 236,000 lb in 1990 and the lowest yield was 25,000 lb in 1995. The large-mesh gill-net fishery has accounted for the entire yield from WFS-06 since 1985 and yield of whitefish from the unit directly parallels changes in large-mesh gill-net effort. Large-mesh gill-net effort ranged from three to four million



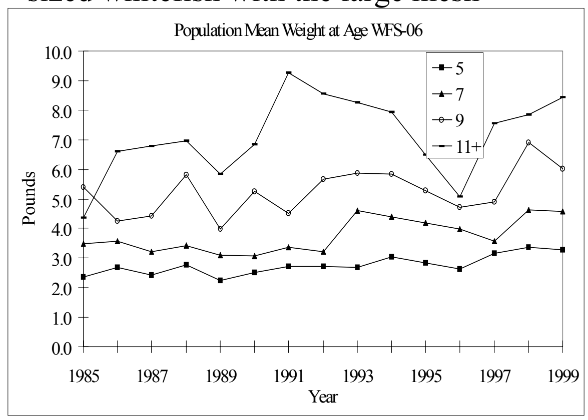
feet during 1985-1991, and then declined to less than two million feet during 1994-1999. Much of the large-mesh gill-net effort in WFS-06 is made up of 5.25- and 5.5-inch stretched mesh.

Whitefish caught in WFS-06 are large sized so the fishery targets them with the large mesh sizes because fishermen are paid 10-50 cents more per pound for medium (3-4 lb) and jumbo (>4 lb) whitefish than for No1 (<3 lb) whitefish. The commercial gill-net yield from WFS-06 was made up of 28% No1, 35% medium, and 37% jumbo whitefish by weight during 1985-1999. Annual mean weight of whitefish in the commercial gill-net yield from WFS-06 ranged from 3.0 to 5.6 lb and averaged 3.8 lb during 1985-1999. The proportion of medium and jumbo whitefish in the yield of WFS-06 is greater than in nearly all other units in the 1836 Treaty waters.

Sexual maturity of whitefish in WFS-06 occurs at larger sizes than for whitefish in lakes Michigan and Huron. Whitefish in WFS-06 do not reach 50% maturity until age 5 and 20 inches long. Complete maturity is not reached until about 24 inches long and age 10.

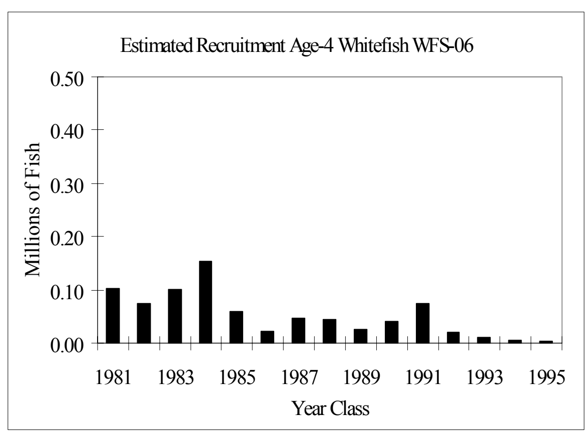
Growth of whitefish in WFS-06 has remained very constant through time. Mean weight of ages 5-11+ whitefish has either remained the same, or increased slightly during 1985-1999.

There may have been a slight increase in mean weight at age for age-5 to age-7 whitefish during the 1990s, but this increase may be because the fishermen in WFS-06 have been targeting larger-sized whitefish with the large mesh



sizes, thus, only the largest members of the younger age classes are actively selected for by the fishery.

Recruitment to the population in WFS-06 has been declining through time based on the stock assessment model. Recruitment of age-4 whitefish to the population in WFS-06 was estimated to range from 60,000 to 150,000 fish for the 1981-1985 year classes, 20,000 to 50,000 for the 1986-1990 year classes,



and 4,000 to 75,000 for the 1991-1995 year classes. The 1998 and 1999 year classes were estimated to contain only 4,800 and 4,300 fish, respectively.

Biomass of the fishable stock of whitefish in WFS-06 has been declining through time because of declines in recruitment. Estimated biomass of whitefish ≥age 4 at the beginning of each year declined from roughly 635,000 lb during 1985-1990, to 333,000 lb during 1997-1999. Fishable stock biomass was estimated to be 385,000 lb during 1990-1999.

Spawning stock biomass has not changed nearly as much as the fishable stock in WFS-06 during 1985-1999. Spawning stock biomass averaged 400,000 lb during 1985-1990 and 309,000 lb during 1997-1999. While biomass of the fishable stock in WFS-06 declined 48% from the mid-1980s to the late 1990s, the spawning stock biomass declined 23%.

Total annual mortality of whitefish in WFS-06 has declined during 1985-1999 because of the reductions in large-mesh gill-net effort. Average total annual mortality of age-5 and older whitefish declined from 55% in 1985 to 25% in 1996, and was 36% in 1999. Average fishing mortality (F) on age-5 and older whitefish was 0.58 in 1985 and declined to 0.07 in 1996, and was 0.22 in 1999. Age-6 whitefish are the most vulnerable to the large-mesh gill-net fishery and fishing mortality on this age class ranged from 0.62 in 1985 to 0.07 in 1996.

Total annual mortality on whitefish vulnerable to the large-mesh gill-net fishery was considerably less than the target rate in WFS-06 during 1997-1999. Total annual mortality of age-5 and older whitefish was only 37% during 1997-1999, but the spawning potential reduction (SPR) value during 1997-1999 was 0.28. The SPR value at the target mortality rate of 65% was only 0.07, well below the acceptable level of 0.20. It appears that there is little room for expanded fishing in WFS-06. The projection model estimated that fishing mortality could be increased 1.3 times in WFS-06 and this rate of fishing would produce an average mortality rate of 41%. The projected yield at the increased level of fishing, accepted by the TFC as the recommended maximum yield for 2001, was estimated to be 63,000 lb.

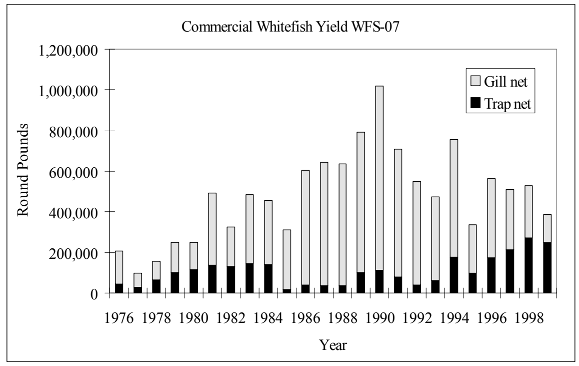
Summary Status – WFS-06 lake whitefish	
Female maturity	
Length at first spawning	18 in
Age at first spawning	3 y
Length at 50% maturity	20 in
Age at 50% maturity	5 y
Spawning stock biomass per recruit	
Base SSBR	8.72 lb
Current SSBR	2.42 lb
SSBR at target mortality	0.58 lb
Spawning potential reduction	
At target mortality	0.07
Average yield per recruit	1.84 lb
Natural mortality (M)	0.22 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	6 y
Fully selected age to trap nets	NA
Average gill net ages 5+	0.24 y^{-1}
Average trap net ages 5+	NA
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0 y^{-1}
Total mortality rate (Z)	
Average 5+ 1997-1999	0.46 y^{-1}
Average 5+ 1999	0.45 y^{-1}
Average 5+ 2001	0.53 y^{-1}
Recruitment (age-4) (1990-1999 average)	29,600 fish
Biomass (age 4+) (1990-1999 average)	385,000 lb
Spawning biomass (1990-1999 average)	301,000 lb
Recommended yield limit in 2001	63,000 lb

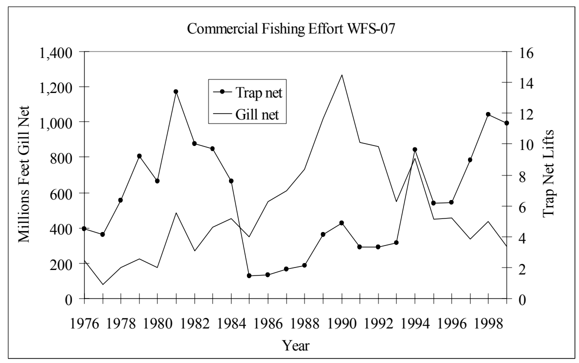
WFS-07 (Tahquamenon Bay Stock)

Prepared by Mark P. Ebener

Management unit WFS-07 is located in the Whitefish Bay area of Lake Superior. The primary geographic feature of WFS-07 is Whitefish Point that divides the unit into two distinct ecological parts. West and north of Whitefish Point is the open water of Lake Superior, while south of the Point includes western Whitefish Bay and a large amount of shallow and relatively warm water for Lake Superior. Maximum depth in the open water portion of WFS-07 is 807 ft., but there is also a large littoral area that extends north into Lake Superior between Whitefish Point and Little Lake Harbor. There is also a large littoral area that extends west into the open water portion of WFS-07 from Canadian waters of Whitefish Bay. Maximum depth in the Whitefish Bay portion of WFS-07 is 330 ft., but much of the area is less than 120 ft. deep. WFS-07 is made up of 12 statistical grids that contain 371,000 surface acres of water <240 ft. deep, out of the unit's total area of 574,000 acres. Sixty-seven percent of the water <240 ft. deep is found in the open water portion of WFS-07.

WFS-07 contains a single, large stock of whitefish that spawns in the Tahquamenon Bay portion of Whitefish Bay. The spawning ground consists of large cobble and rock and extends both north of Naomikong Point into Whitefish Bay and east to Salt Point based on substrate mapping conducted in 1998 and 1999. Mark-recapture data indicated that whitefish tagged in Tahquamenon Bay primarily inhabited





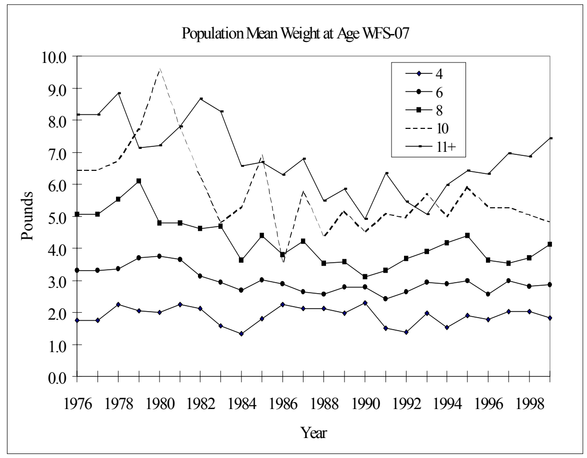
U.S. waters of Whitefish Bay and areas west of Whitefish Point. Tagged whitefish were recaptured as far west as Grand Marais in WFS-06 and Beaver Beach in WFS-05. The spawning stock in WFS-07 also contributes some fish to Canadian waters of Whitefish Bay.

WFS-07 has always been and continues to be a very important area for the tribal fishery. WFS-07 is fished by large- and small-boat gill-net fisheries, trap-net fisheries, and a gill-net fishery under the ice usually takes place every winter. There are a large number of relatively good access sites to the fishing grounds, and there is a reasonable amount of protection from wind and waves in the unit. Because of the access and protection, WFS-07 is a favorite fishing area for small-boat gill-net fishermen on a year-round basis, but particularly in early spring and fall.

The commercial whitefish yield from WFS-07 averaged 480,000 lb during 1976-1999. A peak yield of one million pounds occurred in 1990 and the lowest reported yield was 98,000 lb in 1977. The 1999 yield was 388,500 lb and 62% less than the peak yield in 1990. The large-mesh gill-net fishery has historically accounted for most of the whitefish harvested from WFS-07, but in 1998 and 1999 the trap-net fishery accounted for more of the yield than the gill-net fishery.

Trends in total yield of whitefish from WFS-07 mirrored changes in fishing effort by gill nets and trap nets during 1976-1999. Large-mesh gill-net effort increased from an average of 2.3 million ft. during 1976-1980 to a peak of 14.5 million ft. in 1990, and then declined to 3.4 million ft. in 1999. Trap-net effort increased from 370 lifts in 1976-1977 to 1,171 lifts in 1981 then declined to 128 lifts in 1985. After 1985 trap-net effort increased almost annually to 1,041 lifts in 1998 and 994 lifts in 1999. Regardless of the changes in trap-net effort, total yield of whitefish from WFS-07 was still largely affected by changes in large-mesh gill-net effort.

Whitefish caught in WFS-07 are of moderate to large size. Tribal fisherman typically incorporate 5.25- and 5.5-inch mesh gill nets into their gangs along with the standard 4.5-inch mesh gill net when fishing WFS-07 because of the number of medium- (3-4 lb) and jumbo-size (>4 lb) whitefish in the population. The proportion of the yield made up of the three commercial sizes of whitefish (by weight) was 43% No1 (<3 lb), 30% medium, and 26% jumbo whitefish during 1980-1999. Mean weight of whitefish in the gill-net fishery was 3.3 lb during 1976-1999 and annual mean weight ranged from 2.7 to 3.9 lb. Mean

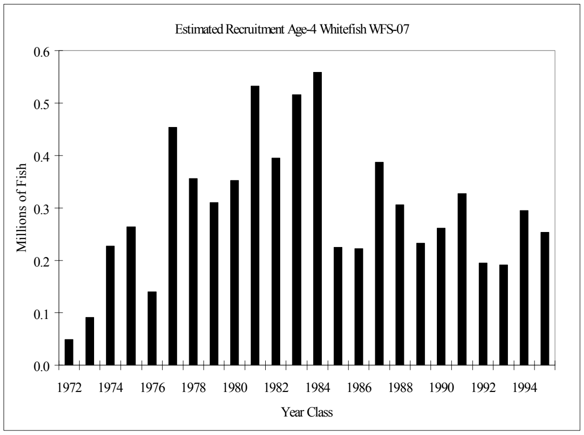


weight of whitefish in the trap-net fishery was 2.8 lb during 1976-1999 and annual mean weight ranged from 2.0 to 3.4 lb.

There appears to have been two directional changes in growth of whitefish in WFS-07. From 1976 to 1990 mean weight at age declined, particularly for whitefish ≥age 6. After 1990 mean weight at age generally increased, but by 1999 no age class weighed more than it did during the late 1970s.

Some whitefish reach sexual maturity in WFS-07 at a small size and young age, but complete maturity of females occurs at a large size and old age. Female whitefish begin reaching sexual maturity at age 3 and about 15 inches long, and by age 5 over 50% of females are sexually mature. After age 5, however, the rate of sexual maturity slows and complete maturity is not reached until whitefish reach 26 inches long and age 12.

Estimated recruitment of age-4 whitefish to the population of WFS-07 varied by 12-fold during 1976-1999. Using the stock assessment model, we estimated that an average of 298,000



age-4 whitefish recruited to the population during 1976-1999. Recruitment varied from only 48,000 fish for the 1972 year class to 559,000 fish for the 1984 year class. Recruitment to the whitefish population increased from the 1972 to the1984 year class, then declined somewhat and stabilized at between 191,000 and 388,000 for the 1985-1995 year classes. The 1995 year class was estimated to contain 254,000 fish.

Estimated biomass of whitefish in WFS-07 peaked just prior to the peak yield and has declined since then. We used the stock assessment model to estimate that biomass of the fishable stock (≥age 4) increased from 570,000 lb in 1977 to 3.4 million lb in 1988, then declined to 2.1 million lb in 1992. Since 1992 fishable stock biomass has been slowly declining and was 1.9 million lb in 1999. Fishable stock biomass of whitefish in WFS-07 averaged 2.0 million lb during 1976-1999 and 2.2 million lb during 1990-1999.

Spawning stock biomass of whitefish in WFS-07 closely followed that of the fishable stock biomass. Spawning stock biomass was 557,000 lb in 1977, it then increased to 3.2 million lb in 1988, declined to 2.0 million lb in 1992, and since 1992 has declined slowly to 1.8 million lb in 1999. Spawning stock biomass averaged 1.9 million lb during 1976-1999 and 2.0 million lb during 1990-1999.

The stock assessment model estimates of fishing mortality (≥age 5) were surprisingly stable and showed no distinct trends during 1976-1999. Fishing mortality (F) averaged 0.43 and annual rates varied from 0.24 to 0.63 during 1976-1999. Fishing mortality was estimated to be 0.39 during 1997-1999 and was 0.33 in 1999. Gill-net fishing mortality averaged 0.18 and trap-net mortality 0.21 during 1997-1999. Peak gill-net mortality was 0.42 in 1990, while peak trap-net mortality was 0.26 in 1998.

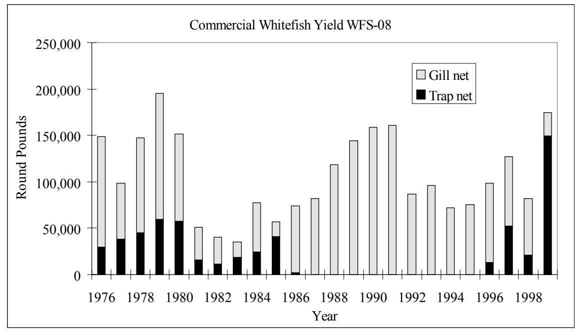
Total mortality of whitefish in WFS-07 was below the maximum target 65%, but the SPR value at current mortality rates was less than the target rate of 0.20. Total mortality of whitefish ≥age 5 averaged 44% during 1976-1999, 42% during 1997-1999, and was 38% in 1999. The current spawning potential reduction value was estimated to be 0.16 during 1997-1999 and only 0.10 at the target mortality rate. As a consequence, the projection model estimated that fishing mortality should be reduced 20% in WFS-07. The projected yield resulting from a 20% reduction in fishing mortality was estimated to be 409,000 lb. This was accepted by the TFC as the recommended maximum yield for 2001.

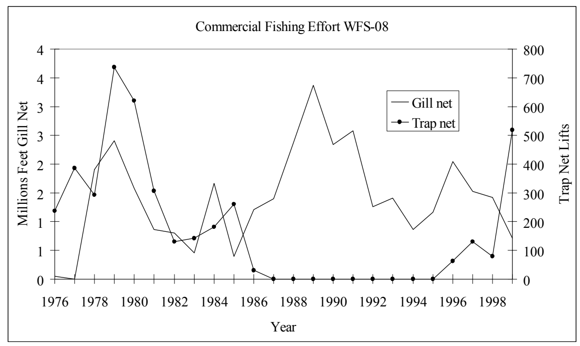
Summary Status – WFS-07 lake whitefish	
Female maturity	
Length at first spawning	15 in
Age at first spawning	3 y
Length at 50% maturity	18 in
Age at 50% maturity	5 y
Spawning stock biomass per recruit	
Base SSBR	12.6 lb
Current SSBR	2.03 lb
SSBR at target mortality	1.30 lb
Spawning potential reduction	
At target mortality	0.10
Average yield per recruit	2.09 lb
Natural mortality (M)	0.15 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	8 y
Fully selected age to trap nets	8 y
Average gill net ages 5+	0.18 y^{-1}
Average trap net ages 5+	0.21 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0 y^{-1}
Total mortality rate (Z)	
Average 5+ 1997-1999	0.54 y^{-1}
Average 5+ 1999	0.48 y^{-1}
Average 5+ 2001	0.46 y^{-1}
Recruitment (age-4) (1990-1999 average)	267,000 fish
Biomass (age 4+) (1990-1999 average)	2,156,000 lb
Spawning biomass (1990-1999 average)	2,005,000 lb
Recommended yield limit in 2001	409,000 lb

WFS-08 (Brimley Stock)

Prepared by Mark P. Ebener

Management unit WFS-08 is located in the very southeast portion of Whitefish Bay, Lake Superior. WFS-08 is ecologically very diverse in that the shallow, upper St. Marys River and substantially deeper offshore waters of Whitefish Bay are included in the unit. Cold-water, cool-water, and warm-water fish species are all commonly caught in WFS-08. Substantial commercial fisheries targeting whitefish also exist in the adjacent Canadian management unit 34. Although WFS-08 is spatially the smallest of the management units in the 1836 Treaty waters of Lake Superior because it is made up of only five statistical grids, the unit contains 160,000 surface acres of waters <240 ft. deep out of 171,000 total acres.

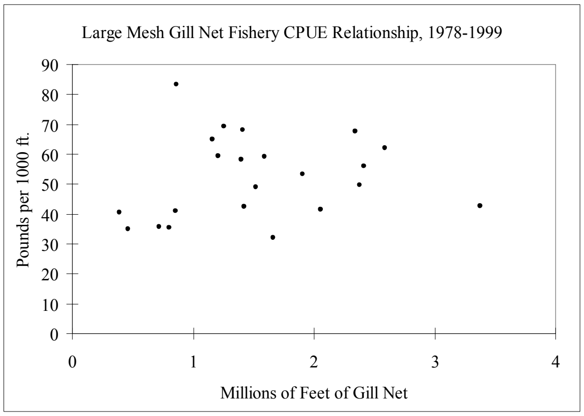


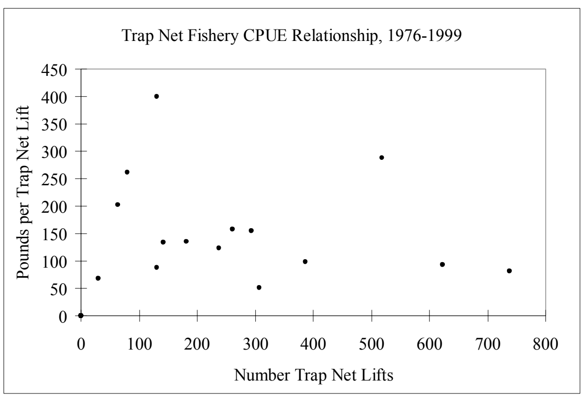


There are probably four reproductively isolated stocks of whitefish that contribute to the commercial fishery in WFS-08. Two areas composed of bedrock, and cobble and rock are located off Iroquois Point and Birch Point in the upper St. Marys River, and small spawning concentrations of whitefish are associated with these areas. Whitefish that spawn in WFS-07 move into WFS-08 during the non-spawning season based on mark-recapture data. In addition, a large spawning concentration of whitefish is found in the Gros Cap area along the Canadian side of the St. Marys River. Undersize whitefish (<17 inches) tagged and released from trap-net catches by CORA staff in WFS-08 in 1983 and 1984 were caught both in WFS-08 and Canadian unit 34. Many of the unit 34 recaptures were made during the spawning season at Gros Cap indicating that many fish that spawn in Canada live in WFS-08 during the non-spawning time period.

WFS-08 has been a traditional commercial fishing area for the tribal small-boat gill net and gill-net ice fishery since the early 1970s. For that matter, members of the CORA tribes have fished WFS-08 commercially and for subsistence for the better part of the last four centuries. There are seven or eight undeveloped landing sites that are commonly used by the small-boat fishery in WFS-08 during the entire open-water fishing season. One or two trap-net operations have also fished WFS-08 on and off since the 1970s.

The commercial yield of whitefish from WFS-08 averaged 106,000 lb during 1976-1999. Annual yields ranged from a low of 35,000 lb in 1983 to a peak of 195,000 lb in 1979. The large-mesh gill-net fishery accounted for 77% of the whitefish yield from WFS-08 during 1976-1999, but in 1999 the trap-net yield exceeded the gill-net yield for the first time. The gill-net yield averaged 82,000 lb and the trap-net yield averaged 24,000 lb during 1976-1999.



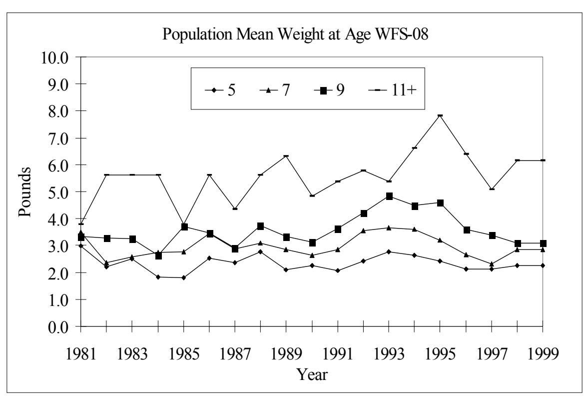


There was a positive linear relationship between large-mesh gill-net effort and the subsequent gill-net yield, whereas there was an asymptotic relationship between trap-net effort and yield in WFS-08. Gill-net effort averaged 1.4 million feet during 1976-1999 and annual effort ranged from 0.7 million feet in 1999 to 3.4 million feet in 1989. Trap-net effort averaged 172 lifts during 1976-1999 and annual effort ranged from 63 lifts in 1996 to 738 lifts in 1979. CPUE in the gill-net fishery did not decline with increased effort during 1976-1999, whereas CPUE in the trap-net fishery did decline somewhat with increased effort during 1976-1999.

Whitefish caught in WFS-08 are of moderate to large size. The proportion of the commercial yield was made up of 52% No1 (<3 lb) whitefish, 22% medium (3-4 lb) whitefish, and 26% jumbo (>4 lb) whitefish during 1980-1999. Mean weight in the gill-net fishery averaged 3.0 lb and annual mean weight ranged from 2.3 to 3.6 lb during 1981-1999. Mean weight in the trap-net fishery averaged 2.4 lb and annual mean weight ranged from 1.9 to 2.8 lb during 1981-1999.

Growth of whitefish in WFS-08 has remained constant through time. Growth, expressed as mean weight at age, did vary somewhat from year to year, but showed no consistent trends through time as in Lakes Michigan and Huron. For example, mean weight of an age-8 whitefish was 3.5 lb in 1981 and 1991 and 3.2 lb in 1999, while mean weight of an age-10 fish was 4.3 lb in 1981, 4.4 lb in 1991, and 4.3 lb in 1999.

Whitefish in WFS-08 mature earlier and at smaller sizes than in WFS-07.



Female whitefish begin maturing at 15 inches and age 3 in WFS-08 and two-thirds are sexually mature by age 4.

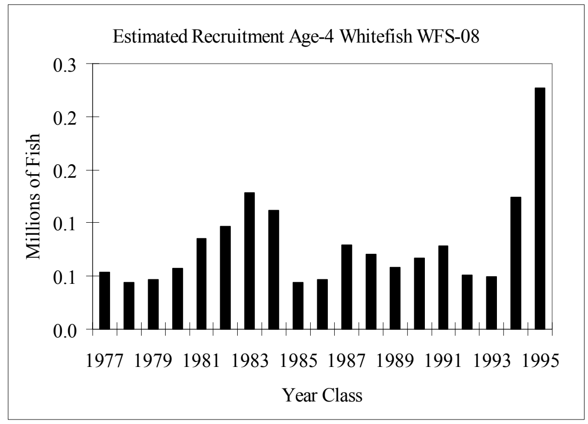
Complete maturity is reached by 23 inches and age 11 and older.

Recruitment of age-4 whitefish to the population in WFS-08 has been very consistent. Estimated annual recruitment of age-4 whitefish based on the stock assessment model ranged from 44,000 fish in 1978 and 1985 to 227,000 fish in 1999. Recruitment to the population of WFS-08 was estimated to average 80,000 fish during 1976-1999 and 85,000 fish during 1990-1999. This is surprisingly stable recruitment considering other stocks in the 1836 Treaty waters have varied up to 60 fold.

Because whitefish in WFS-08 mature at a young age and small size, biomass of the fishable and spawning stock vary concurrently. Fishable stock biomass averaged 434,000 lb during 1976-1999 and annual fishable biomass ranged from 216,000 lb in 1982 to 681,000 lb in 1999. Spawning stock biomass averaged 451,000 lb during 1976-1999 and annual spawning stock biomass ranged from 176,000 lb in 1982 to 748,000 lb in 1999.

The large-mesh gill-net fishery accounted for most of the fishing-induced whitefish mortality in WFS-08. Fishing mortality on whitefish ≥age 5 was estimated to average 0.55 during 1976-1999 and the gill-net fishery accounted for 77% of this mortality. Annual gill-net mortality ranged from 0.15 in 1983 to 0.82 in 1991, while trap-net mortality ranged from 0 during 1987-1995 to 0.76 in 1999. Gill-net mortality was estimated to be 0.17 in 1999. Total annual mortality rate on whitefish ≥age 5 averaged 51% during 1976-1999 and in all but 1999 was less than the target rate of 65%.

Total mortality rate was estimated to be 67% on whitefish ≥age 5 in 1999 and



the spawning potential reduction (SPR) value was 0.19. Because peak mortality was greater than the target rate and SPR was less than 0.20 in WFS-08, the projection model indicted that fishing mortality should be decreased 8% from levels in 1997-1999. The yield at the reduced fishing rate was estimated to be 176,000 lb in 2001, and this was accepted as the recommended maximum yield for 2001. The recommended yield for 2001 is projected to be greater than the recent harvests because the 1994 and 1995 year classes were much larger than the previous nine year classes.

Summary Status – WFS-08 lake whitefish	
Female maturity	
Length at first spawning	15 in
Age at first spawning	3 y
Length at 50% maturity	18 in
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	7.57 lb
Current SSBR	1.45 lb
SSBR at target mortality	1.40 lb
Spawning potential reduction	
At target mortality	0.19
Average yield per recruit	1.59 lb
Natural mortality (M)	0.17 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	9 y
Fully selected age to trap nets	9 y
Average gill net ages 5+	0.31 y^{-1}
Average trap net ages 5+	0.36 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0 y^{-1}
Total mortality rate (Z)	
Average 5+ 1997-1999	0.85 y^{-1}
Average 5+ 1999	1.10 y^{-1}
Average 5+ 2001	0.79 y^{-1}
Recruitment (age-4) (1990-1999 average)	85,000 fish
Biomass (age 4+) (1990-1999 average)	434,000 lb
Spawning biomass (1990-1999 average)	451,000 lb
Recommended yield limit in 2001	176,000 lb

LAKE HURON

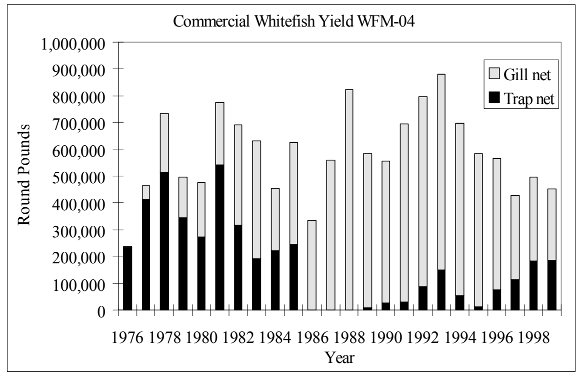
WFH-01 (St. Ignace Stock)

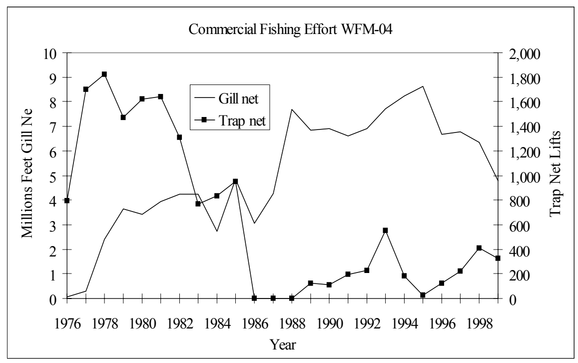
Prepared by Mark P. Ebener

Whitefish management unit WFH-01 is located in the very northwest portion of the main basin of Lake Huron and is considered part of the Straits of Mackinac. There are seven islands located in WFH-01; Marquette, Goose, Big and Little St. Martin, Mackinaw, Round, and Bois Blanc. WFH-01 is relatively shallow as most water in the unit is less than 150 ft. deep. Seven statistical grids make up WFH-01 and contain 232,275 surface acres all of which is <240 ft. deep.

There are probably several reproductively isolated stocks of lake whitefish that inhabit WFH-01. One stock of fish spawns along the outer portion of Marquette Island, another spawns in central and eastern St. Martin Bay, a third spawns in Horseshoe Bay north of St. Ignace, and a fourth spawns near Cheboygan, Michigan. CORA gill-net surveys during November have captured lake whitefish in spawning condition in Horseshoe Bay in 1984, near Cheboygan during 1987-1988, and in St. Martin Bay during 1992-1995.

WFH-01 has been an exclusive fishing zone for the tribal fishery since 1985 and is a favored fishing area for small-boat gill-net fishermen. In most years some gill-net fishing is conducted under the ice in St. Martin Bay. Commercial yields of whitefish have ranged from 46,000 lb in 1976 to 806,000 lb in 1994 and averaged 523,000 lb during 1990-1999. The commercial yield declined from 1995 through 1999 and was 291,000 lb in 1999.



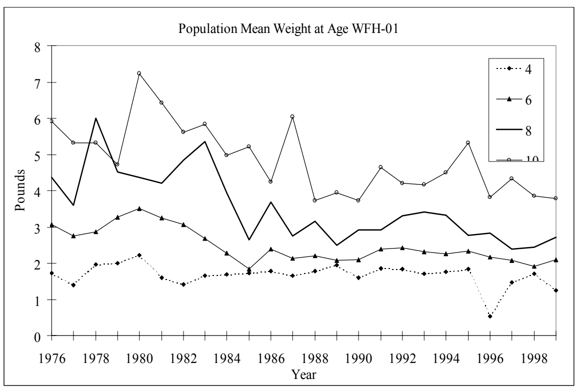


Large-mesh gill nets have taken the majority of whitefish from WFH-01 during 1976-1999. From 1976 to 1984 large-mesh gill nets accounted for 0-41% of the annual whitefish yield, while after 1985 gill nets accounted for 52-75% of the annual yield.

Large-mesh gill-net effort increased almost annually from 1982 to 1999, but effort in 1999 was lower than during the peak years of 1994-1996. Since peaking in 1982, the trap-net yield has continually declined due primarily to reductions in trap-net effort. Trap-net effort ranged from 1,020 to 1,357 lifts during 1981-1984 and from 217 to 477 lifts during 1996-1999.

Whitefish in WFH-01 are of small size with over 90% (by weight) of the yield being made up of No1 fish (<3 lb). Mean weight of whitefish in the trap-net harvest is typically smaller than in the gill-net harvest with annual mean weight ranging from 2.0 to 2.3 lb in the trap-net fishery and 2.2 to 2.6 lb in the gill-net fishery during 1990-1999.

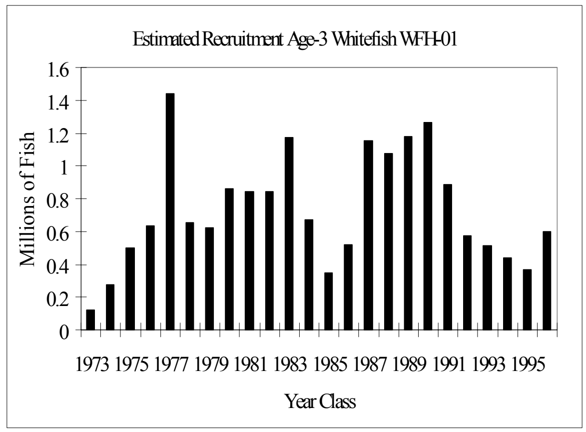
Growth of lake whitefish in WFH-01 has been declining steadily since the late 1970s and this decline has affected recruitment to both the fishable and spawning stock. The decline in growth



is most evident in the size-at-age of fish age 6 and older. Age-4 whitefish were the modal age class in the trap-net fishery during 1976-1981, but by 1995-1999 age-4 whitefish were barely represented in the trap-net harvest and the modal age was 6 or 7. The proportion of age-4 female whitefish that were sexually mature declined from 66% during 1976-1982, to 44% during 1983-1992, and to 29% during 1993-1999. All age-6 and older female whitefish were sexually mature during 1976-1982, but only 87% were sexually mature by 1995-1999.

Large year classes of whitefish were produced during 1987-1991 while average- to poor-sized year classes were produced during 1992-1996 in WFH-01. The stock assessment model estimated that recruitment of age-3 fish to the population averaged 1.1 million fish for the 1987-1991 year classes, but only 470,000 fish for the 1992-1996 year classes. Future yields of whitefish in WFH-01 will decline as the 1992-1996 year classes recruit into the fishery.

Estimated biomass of whitefish ≥age



3 at the beginning of each year (fishable stock) averaged 3.26 million lb during 1990-1999. Annual estimated biomass of these fish increased from 2.84 million lb in 1990 to 4.45 million lb in 1994, then declined to 1.90 million lb in 1999.

Spawning stock biomass averaged 2.06 million lb during 1990-1999 and represented about 63% the biomass available at the beginning of the year. Spawning stock biomass increased from 1.76 million lb in 1990 to 2.69 million lb in 1994 then declined to 1.35 million lb in 1999. We expect both spawning stock and fishable biomass to continue to decline for several years.

Sea lampreys continue to kill a substantial number of whitefish in WFH-01 based on observed wounding. We estimated that annual sea lamprey-induced deaths ranged from 27,000 to 45,000 in WFH-01 during 1990-1999 and averaged 35,000 fish during the same time period.

Fishing mortality induced by the gill-net fishery was the largest single source of mortality in WFH-01. Fishing mortality (F) on age-4 and older whitefish (4+) from gill nets averaged 0.25 during 1997-1999 compared to 0.09 for the trap-net fishery during the same time period.

Total mortality rate (Z) on the fishable stock of ages 4 and older was less than the target mortality rate of 1.05 (65%) during 1997-1999. Based on age-specific mortality and reproductive schedules, the present spawning potential reduction (SPR) was estimated to be 0.35, well above the minimum acceptable level of 0.20 as defined by the modeling subcommittee. Thus, the projection model indicted that fishing mortality in 2001 could be increased by roughly 1.2 times from the 1997-1999 level. These rates of fishing were projected to produce an estimated yield of 327,000 round lb. This yield seems realistic given the declines in recruitment that have taken place since 1993, and was accepted by the TFC as the recommended maximum yield for 2001.

Summary Status – WFH-01 lake whitefish	
Female maturity	
Length at first spawning	15 in
Age at first spawning	3 y
Length at 50% maturity	18 in
Age at 50% maturity	5 y
Spawning stock biomass per recruit	
Base SSBR	1.96 lb
Current SSBR	0.68 lb
SSBR at target mortality	0.57 lb
Spawning potential reduction	
At target mortality	0.29
Average yield per recruit	0.62 lb
Natural mortality (M)	0.27 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	8 y
Fully selected age to trap nets	8 y
Average gill net ages 4+	0.25 y^{-1}
Average trap net ages 4+	0.09 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0.06 y^{-1}
Total mortality rate (Z)	
Average 4+ 1997-1999	0.67 y^{-1}
Average 4+ 1999	0.62 y^{-1}
Average 4+ 2001	0.74 y^{-1}
Recruitment (age-3) (1990-1999 average)	805,000 fish
Biomass (age 3+) (1990-1999 average)	3,257,000 lb
Spawning biomass (1990-1999 average)	2,064,000 lb
Recommended yield limit in 2001	327,000 lb

WFH-02 (Detour Stock)

Prepared by Mark P. Ebener

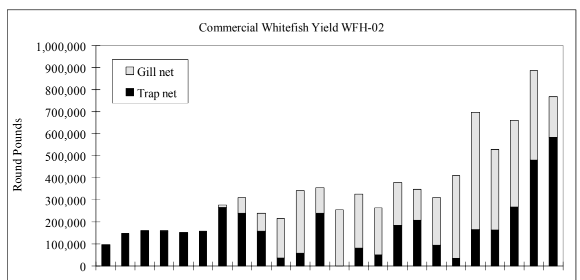
Management unit WFH-02 is located along the northern shore of the main basin of Lake Huron. The Les Cheneaux Islands form the western portion of WFH-02, while the eastern boundary is the western end of Drummond Island. The St. Marys River discharges into the eastern end of WFH-02 through the Detour Passage. The entire shoreline of WFH-02 is part of the Niagara Escarpment and composed of dolomite limestone that produces an irregular shoreline containing many small rocky points, isolated bays, and scattered large boulders. Much of WFH-02 is deeper than 150 ft and the maximum depth is slightly greater than 300 ft. WFH-02 is a small unit that is made up of only three statistical grids that contain 122,562 surface acres <240 ft. deep, representing roughly 80% of the total area in the unit.

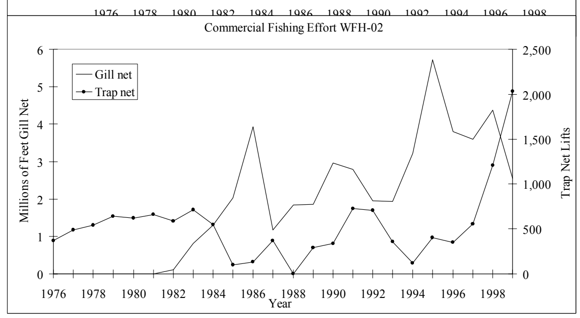
Because the shoreline of WFH-02 is highly irregular and rocky, nearly the entire unit contains suitable habitat for reproduction. The largest concentration of spawning lake whitefish is located in the middle of the unit between Albany Island and Saddle Bag Islands. CORA gill-net surveys during November have captured lake whitefish in spawning condition at Saddle Bag Islands in 1987-88. Young-of-the-year lake whitefish <50 mm long were caught in day-time shore seines directly adjacent to Saddle Bag Islands by CORA staff in 2000.

WFH-02 has been an exclusive tribal fishing zone since the 1985 Consent Order, but the structure of the tribal fishery here has changed considerably. From 1982 when CORA member tribes could first fish WFH-02 through 1984, WFH-02 was primarily a small boat gill-net fishing area, particularly in the early spring. After 1985 several large gill-net boats began fishing WFH-02. After 1995 the number of large gill-net boats fishing WFH-02 declined as several trap-net operations started fishing in the unit.

The yield of lake whitefish from WFH-02 has increased steadily through the years. Total yield increased from a low of 99,000 lb in 1976 to a peak of 888,000 lb in 1998 and averaged 352,000 lb during 1976-1999. The total yield of whitefish from WFH-02 was 768,000 lb in 1999.

The allocation of the yield among gill nets and trap nets changed with the structure of the fishery. Prior to 1985 trap nets made up 66-100% of the total yield, while during 1985-1997 large-mesh gill nets made up 36-92% of the yield. The conversion from a gill-net to a trap-net fishery by several tribal



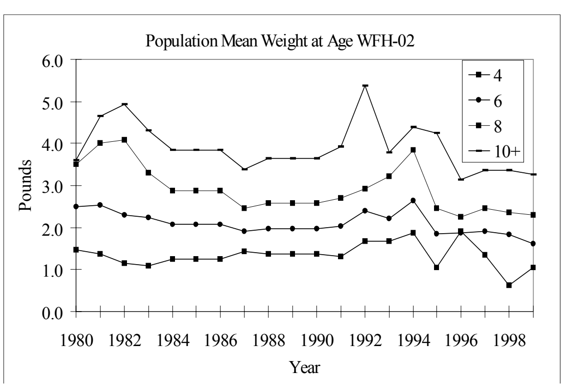


fishermen in 1997 changed the allocation of the yield again as trap nets made up 76% of the yield in 1999.

Both large-mesh gill-net and trap-net effort have changed markedly in WFH-02 since 1976. Trap-net effort averaged about 500 lifts annually from 1976 to 1984, varied between zero and 727 lifts from 1985 to 1997, then increased dramatically to 1,200 and 2,000 lifts in 1998 and 1999, respectively. Large-mesh gill-net effort increased from 0.8 million ft in 1982 to 5.7 million ft in 1995, then declined to 2.5 million ft in 1999.

Whitefish in WFH-02 are of small size with 90% (by weight) of the yield being made up of No1 fish (< 3 lb) during 1980-1999. Size structure of the population has shifted some toward larger fish recently, with 84% of the yield being No1 fish, 14% mediums (3-4 lb), and 2% jumbos (>4 lb) in 1999. Trap-net caught whitefish are usually smaller than gill-net fish as annual mean weight in the trap-net fishery ranged from 2.0 to 2.6 lb during 1990-1999 and mean weight in the gill-net fishery ranged from 2.3 to 2.7 lb during 1990-1999.

Whitefish recruit to the trap-net fishery at a younger age than to the gill-net fishery. Whitefish begin entering the trap-net fishery by age 4 and by age 8 they are completely vulnerable to the trap-net fishery. Age-5 whitefish are the first commonly caught age class in the gill-net fishery, and by age 8 they are completely vulnerable to the gill-net fishery. Ages 4-10 and 5-10 make up >95% of the trap-net and gill-net yield, respectively.



Weight at age has been declining since the 1970s and this decline in growth rate is affecting recruitment to both the fishable and spawning stock in WFH-02. Mean weight at age did increase somewhat in the early 1990s from lows seen in the late 1980s, but by 1998 and 1999 all age classes weighed less than any time during 1976-1999. In the early 1980s age-5 whitefish were often the modal age in the trap-net fishery, but by 1999 the modal age in the trap-net fishery was age-6 or age-7 whitefish. About 25% of age-3 whitefish were sexually mature in 1980-1982, but by 1995-1999 only 6% of age-3 fish were sexually mature. The proportion of age-5 fish that are sexually mature declined from 98% in 1980-1982, to 86% during 1983-1994, and declined further to 74% during 1995-1999.

A distinct characteristic of the whitefish stock in WFH-02 is their small size at sexual maturity. Some females are sexually mature by 14 inches and 50% of females are mature at 15.7 inches long. Some females are mature as young as age-3, and 50% are mature by age 6.

We could not obtain reliable estimates of mortality and abundance of whitefish in WFH-02 during 1998 and 1999 because of the large increase in trap-net effort during these years. Mortality rates in the stock assessment model are linked to fishing effort, and since trap-net effort increased 17-fold from 1994 to 1999, the model continually estimated total mortality of fully vulnerable ages to be >90% even when we down-weighted the relationship between effort and catch. The high mortality rates did not correspond well with the expanding age and size structure of the whitefish stock in WFH-02. For example, the proportion of age-9+ whitefish in the trap-net harvest was 9 and 11% in 1998 and 1999, respectively, but had never exceeded 6% prior to 1998. This expanding age composition suggests that fishing effort was not large enough to erode the age structure of the population during 1998 and 1999.

Estimates of a biological based yield level were not projected with the spreadsheet model because reliable estimates of stock size and mortality were not produced with the stock assessment model. The recommended maximum yield for 2001 is 620,000 to 650,000 round lb, and represents a compromise by the modeling subcommittee and TFC between the average yield of 708,000 lb during 1995-1999 and the lower yields experienced prior to 1995.

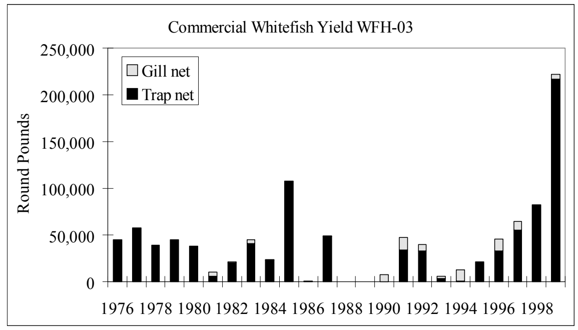
WFH-03 (Drummond Island Stock)

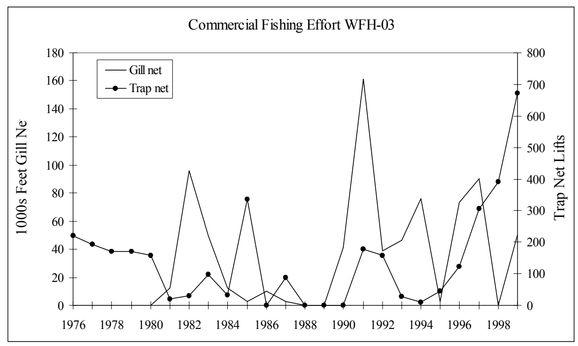
Prepared by Mark P. Ebener

WFH-03 is a small management unit adjacent to Drummond Island that contains three distinct physical parts. The south side of Drummond Island is part of the main basin of Lake Huron and makes up the majority of the fishable waters in the unit. Almost the entire south shore of Drummond Island is a refuge for lake trout where gill-net fishing is prohibited and retention of lake trout by trap-net fisheries is prohibited. The south side is deep with much of the water exceeding 150 ft. deep, whereas the other sides of Drummond Island are part of the North Channel and St. Marys River and much shallower and warmer than the south side. WFH-03 contains six statistical grids and <90,000 surface acres of water < 240 ft. deep, representing roughly 90% of the total area.

All of WFH-03 lies within the Niagara Escarpment and is composed of dolomite limestone. The spawning shoals for lake whitefish in this unit are located along the south shore of Drummond Island in the main basin. Adult whitefish in spawning condition have been caught primarily between Seaman Point and Big Shoal by CORA staff during gill-net surveys made in October of 1991-2000.

WFH-03 has been an exclusive fishing zone for the tribal fishery since 1985. The unit is primarily a trap-net fishery because of the refuge along the southern shore of Drummond Island. A winter gill-net fishery for lake whitefish takes place in the North Channel from January through mid-March of most years. The trap-net fishery takes place along the south shore of Drummond Island and into the False Detour Passage along the U.S.-Canadian border. Very little trap-net fishing occurs in the North Channel. The trap-net fishery occurs nearly year-round in WFH-03 because ice seldom forms along the south shore of Drummond Island.



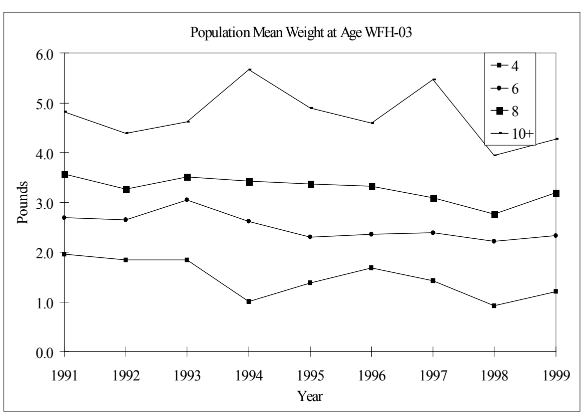


The annual commercial yield of whitefish from WFH-03 averaged only 43,000 lb during 1976-1999, and only in 1985 and 1999 did the commercial yield exceed 100,000 lb. The annual gill-net yield ranged from 0 to 13,300 lb during 1976-1999, while the trap-net yield from 0 to 217,000 lb during 1976-1999.

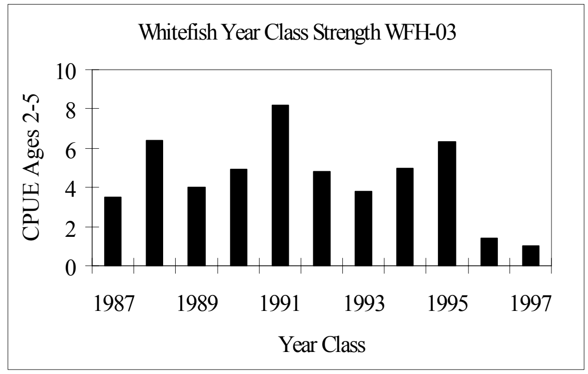
The huge increase in trap-net yield in 1999, from that experienced in previous years, was due to an increase in trap-net effort from 392 lifts in 1998 to 673 lifts in 1999. Trap-net effort in WFH-03 increased 67-fold from 1994 to 1999. Gill-net effort averaged only about 32,000 ft. annually from 1976 to 1999 and showed little trend through time.

Whitefish caught in the fishery of WFH-03 are moderate sized. During 1987-1999 68% (by weight) of the whitefish yield were No1 fish (<3 lb), 24% were mediums (3-4 lb), and 8% were jumbos (>4 lb). Mean weight of whitefish in the trap-net fishery ranged from 2.0 to 2.8 lb and averaged 2.5 lb during 1991-1999. Whitefish harvested by the gill-net fishery were substantially larger than in the trap-net fishery. Mean weight in the gill-net fishery ranged from 2.3 to 3.0 lb and averaged 2.9 lb during 1991-1999.

Growth of whitefish in WFH-03 has been more stable than growth in the more western management units of Lake Huron. Mean weight at ages 4, 6, 8, and 10+ did decline somewhat during 1991-1999 in WFH-03 based on catches made during CORA graded mesh gill-net surveys, but the declines were not as severe as in WFH-01, WFH-04, and WFH-05.



Relative abundance of the 1987-1995 year classes of whitefish in WFH-03 was relatively consistent and good, but the 1996 and 1997 year classes appear to be much less abundant based on CORA

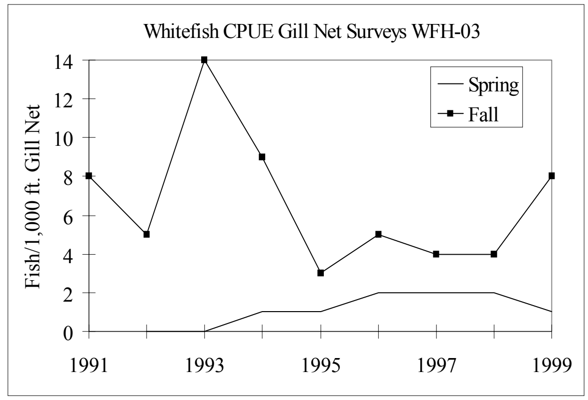


graded mesh gill-net surveys. The 1991-1995 year classes were abundant and have made up the bulk of the yield from the unit during the 1990s, but commercial yields will decline in the future as the weak year classes recruit to the fishery.

Whitefish in WFH-03 reach sexual maturity at larger sizes and older ages than in the adjacent unit WFH-02. The proportion of sexually mature female whitefish in CORA catches from WFH-03 was 6% at 15 inches, 29% at 17 inches, 50% at 19 inches, and 100% at 21 inches long during 1991-1999. Age-specific maturity of female whitefish was 7% at age 3, 37% at age 5, and 77% at age 7. In no age class were 100% of the females sexually mature in WFH-03 during 1991-1999.

We could not produce reliable estimates of mortality and abundance in WFH-03 with the stock assessment model because the time period under consideration may have been too short. Input data for the stock assessment model spanned 1991-1999 and no independent survey data was input to the model to assist with estimating mortality and abundance. Estimates of abundance generated with the model tended to vary by factors of 2-3 fold for a given year class when even small changes were made to the natural logarithm of the prior estimate about the stock-recruitment relationship. This occurred even when convergence criteria were met within the stock assessment model

The TFC's recommended maximum yield for 2001 in WFH-03 is 220,000-250,000 lb and reflects the 1999 yield level and trends in abundance observed in CORA graded mesh gill-net surveys conducted during 1991-1999.



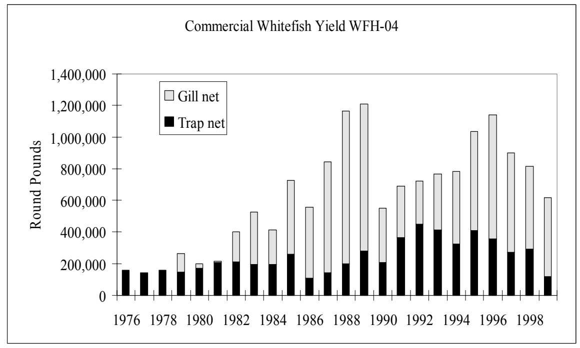
WFH-04 (Hammond Bay Stock)

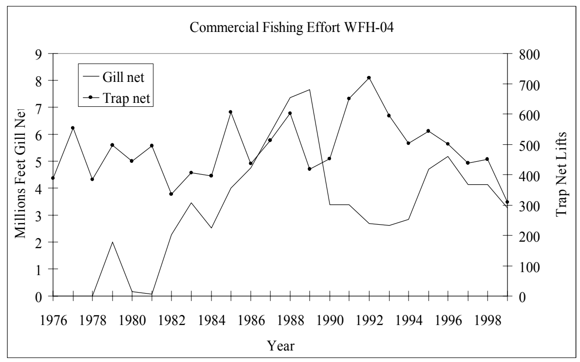
Prepared by Mark P. Ebener

WFH-04 is the largest whitefish management unit in the 1836 Treaty waters of Lake Huron. The unit extends from the southeast corner of Bois Blanc Island near Cheboygan, Michigan, southeast to Presque Isle between Rogers City and Alpena, Michigan. Eight statistical grids are adjacent to the shoreline of WFH-04, while another 16 statistical grids lie offshore. Maximum depth of water in this unit is 500 ft. and most of the water in the unit is >240 ft. deep. WFH-04 contains 377,567 surface acres of water <240 ft. deep, representing about 25% of the total area.

Spawning concentrations of whitefish are scattered throughout the unit with concentrations being found near Cheboygan, Michigan, and Hammond Bay. Some spawning may take place near Presque Isle. Whitefish in spawning condition were captured near Cheboygan and in Hammond Bay by CORA staff during 1986-1988.

WFH-04 has always been an important fishing area for both tribal and state-licensed fisheries. WFH-04 waters north of 40-Mile Point have been an exclusive fishing zone for tribal fishermen since 1985, while waters south of 40-Mile Point have been an exclusive fishing area for state-licensed trap-net fishermen. The Consent Decree now prohibits state-licensed commercial fishing in this area. The Hammond Bay area south of the Refuge area was closed to tribal large-mesh gill-net fisheries beginning in 1991 and from 1991 to 1999 one tribal trap-net fishery operated in Hammond Bay. Waters north of the





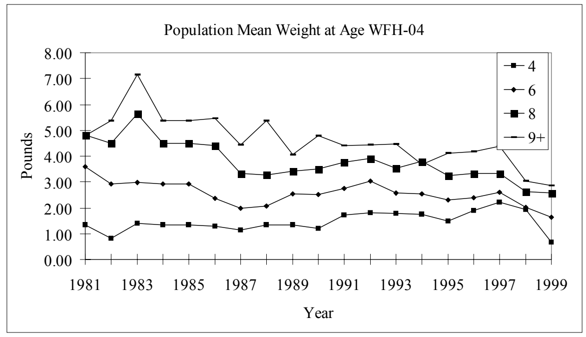
Hammond Bay Refuge Harbor have been open to gill-net fishing since 1982. WFH-04 has traditionally been an important fishing area for small-boat gill-net fisheries.

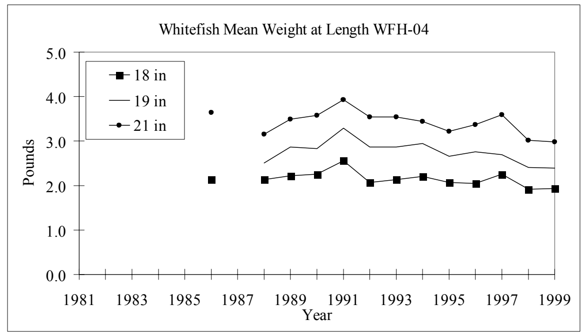
The large-mesh gill-net fishery has harvested the majority of the whitefish from WFH-04. The annual total yield of whitefish averaged 625,000 lb from WFH-04 during 1976-1999 and the gill-net fishery accounted for 61% of that yield. The annual gill-net yield for individual years ranged from 3% in 1981 to 81% in 1999. The peak yield of whitefish from WFH-04 was 1.2 million lb in 1989 and the gill-net fishery accounted for 77% of that yield. The annual trap-net yield averaged 241,000 lb and ranged from a low of 111,000 lb in 1986 to 450,000 lb in 1992.

Both large-mesh gill- and trap-net effort has declined during the last few years. Large-mesh gill-net effort peaked at 7.7 million feet in 1989 then declined 66% thereafter to only 2.6 million ft in 1993. Annual trap-net effort was variable yet stable from 1976 to 1991, increased to a peak of 719 lifts in 1992, and declined nearly annually thereafter. Fishing effort in 1999 was made up of 3.3 million feet of large-mesh gill net and 309 trap-net lifts.

Whitefish from WFH-04 are of moderate size and somewhat larger than fish from more northern areas of Lake Huron. The proportion (by weight) of No1 (<3 lb), medium (3-4 lb), and jumbo (>4 lb) whitefish in the tribal commercial yield was 63%, 25%, and 11%, respectively, during 1982-1999. Annual mean weight of whitefish in the gill-net yield ranged from 2.6 to 3.0 lb during 1982-1999, while mean weight in the trap-net fishery ranged from 2.7 to 3.6 lb and averaged 2.7 lb. The primary reason whitefish caught in the trap-net fishery are larger than those caught in the gill-net fishery is because the minimum total length limit is 19 and 18 inches for the state-licensed fishery and tribal trap-net fisheries, respectively.

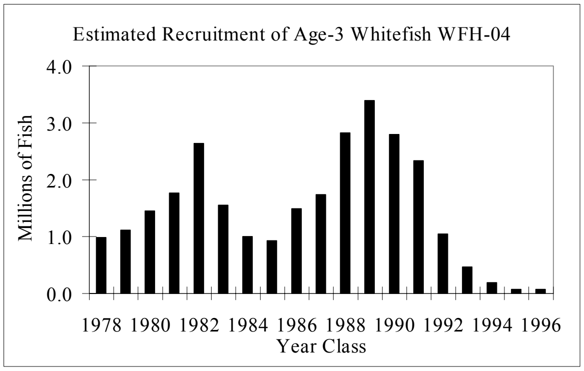
Growth rate of whitefish from WFH-04 has declined substantially through the years and condition has declined since the early 1990s. Mean weight of age-9+ fish declined from about 5.5 lb in the early 1980s to only 2.9 lb in 1999, whereas mean weight of age-6 whitefish declined about 2.9 lb in the early 1980s to 1.6 lb in 1999. The decline in condition, expressed as mean weight at a given length, of whitefish caught in the tribal trap-net fishery was lower for 18-, 19-, and 21-inch fish in 1999 than in any other year. These declines in growth have been occurring since 1992.





Sexual maturity of female whitefish in WFH-04 is similar to that in WFH-01 and WFH-03. Less than 5% of female whitefish in WFH-04 first become sexually mature at about 15 inches long and three years old, but 50% of female whitefish are not sexually mature until about 18 inches long and five years old. All female whitefish larger than 21.3 inches and age 9 and older are sexually mature in WFH-04.

The stock assessment model indicated that recruitment to the fishery population declined substantially after 1992. Recruitment of age-3 whitefish to the fishable population averaged 1.5 million fish during 1990-1999. A series of good year classes were produced in 1988-1991 and have supported the fishery in WFH-04 since the mid-1990s. Declines in yield of whitefish in WFH-04 can be expected if the recruitment predicted with the stock assessment model is realized. The most abundant



year class estimated by the model was 1989 at 3.4 million age-3 fish, and the smallest year classes were the 1995 and 1996, at 76,000 fish.

Biomass of whitefish ≥age 3 at the beginning of each year averaged 6.6 million lb during 1981-1999 and 7.6 million lb during 1990-1999. Peak fishable stock biomass was estimated to be 11.2 million lb in 1994 and the minimum biomass was 2.1 million lb in 1999. Estimated fishable biomass was lower in 1998 and 1999 than any other time during 1981-1999.

Estimated spawning stock biomass averaged 4.1 million lb during 1981-99 and 4.9 million lb during 1990-1999. Peak spawning stock biomass was 7.6 million lb in 1995 and the smallest spawning stock biomass during 1981-1999 was 1.9 million lb in 1999. Estimated spawning stock biomass in 1995 was nearly two-fold greater than during any other year in the stock-assessment model.

We estimated that sea lamprey killed many whitefish in WFH-04, although sea lamprey-induced mortality rate averaged only 5%. Based on wounding data and model estimates of whitefish abundance, we estimated that an average of 76,000 whitefish were killed annually by sea lamprey, ranging from 37,500 fish in 1981 to 126,000 fish in 1995.

Mortality induced by the gill-net fishery was the largest single source of fishing mortality during 1981-1999. Gill net-induced mortality (F) on whitefish ≥age 4 averaged 0.17 during 1997-1999 compared to 0.06 for trap nets. Gill net-induced mortality was greater in 1989 than other years, while trap-net-induced mortality was greatest in 1992.

Total annual mortality rate on whitefish ≥age 4 was less than the target rate during 1997-1999. The spawning potential reduction value was 0.34 during 1997-1999, therefore, the projection model indicted that fishing mortality could be increased 1.95 times from the 1997-1999 levels. Even so, because of the low level of recruitment estimated for recent years, the projected yield level with the spreadsheet model (263,000 lb)was substantially less than the average yield during 1997-1999. Consequently, the average yield during 1997-1999 of 787,000 lb was adopted as the tribal harvest regulation guideline for 2001.

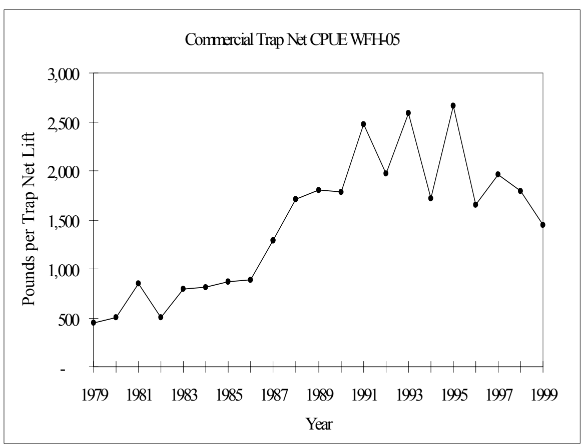
Summary Status – WFH-04 lake whitefish	
Female maturity	
Length at first spawning	15 in
Age at first spawning	3 y
Length at 50% maturity	18 in
Age at 50% maturity	5 y
Spawning stock biomass per recruit	
Base SSBR	1.05 lb
Current SSBR	0.36 lb
SSBR at target mortality	0.23 lb
Spawning potential reduction	
At target mortality	0.21
Average yield per recruit	0.38 lb
Natural mortality (M)	0.32 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	8 y
Fully selected age to trap nets	9 y
Average gill net ages 4+	0.16 y^{-1}
Average trap net ages 4+	0.06 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0.05 y^{-1}
Total mortality rate (Z)	
Average 4+ 1997-1999	0.59 y^{-1}
Average 4+ 1999	0.63 y^{-1}
Average 4+ 2001	0.80 y^{-1}
Recruitment (age-3) (1990-1999 average)	1,496,000 fish
Biomass (age 3+) (1990-1999 average)	7,618,000 lb
Spawning biomass (1990-1999 average)	4,882,000 lb
Harvest regulation guideline in 2001	787,000 lb

WFH-05 (Alpena Stock)

Prepared by Mark P. Ebener

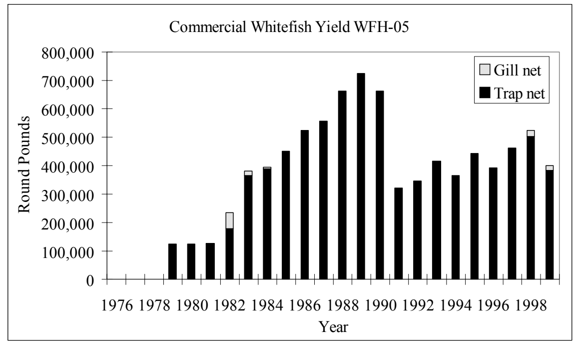
WFH-05 runs from Presque Isle south to North Point and includes some waters that lie outside the 1836 Treaty waters. Twelve statistical grids are located in the unit, but fishing for whitefish occurs only in four of these because the others are too deep for fishing whitefish. Maximum depth in WFH-05 exceeds 600 ft. and much of the unit is deeper than 240 ft. There are an estimated 209,000 surface acres of water <240 ft. deep in WFH-05, representing about 30% of the total area.

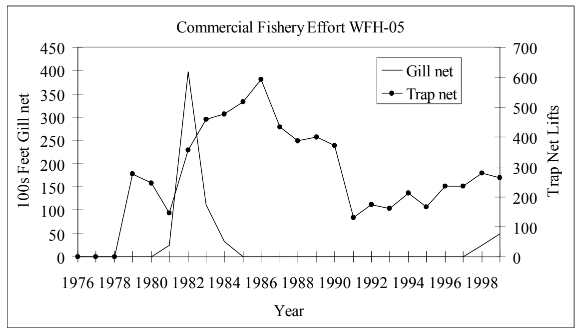
WFH-05 contains a single, very large spawning stock of whitefish. The stock spawns in the area from Middle Island to south of North Point. Commercial gill- and trap-net catches of whitefish in WFH-05 during late October and early November are tremendous. Catches of 1,900 lb of whitefish per 1,000 ft. of 4.5-inch mesh gill net and over 10,000 lb of



whitefish per trap-net lift are common in the fall.

WFH-05 had been an exclusive fishing zone for two state-licensed trap-net fisheries since 1985. Only a few tribal small-boat gill-net fisheries



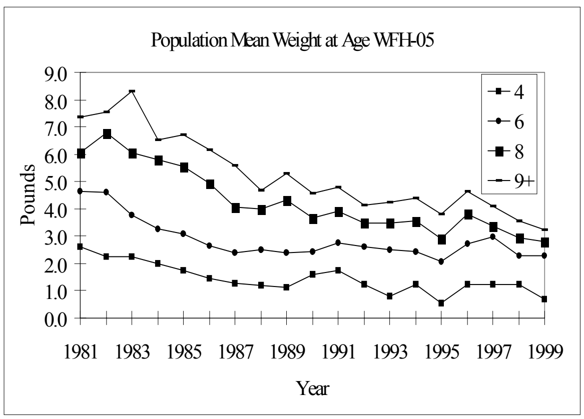


ventured into WFH-05 prior to 1985, and a gill-net assessment fishery operated briefly here in 1998 and 1999. The Consent Decree allocated all commercial yields of whitefish in this area to CORA tribes. The trap-net fishery operates primarily in the October, fishes in waters <40 ft. deep, and can only retain fish ≥19 inches total length. Catch rates in the trap-net fishery are very large with average annual catch per unit effort (CPUE) sometimes exceeding 2,000 lb per lift.

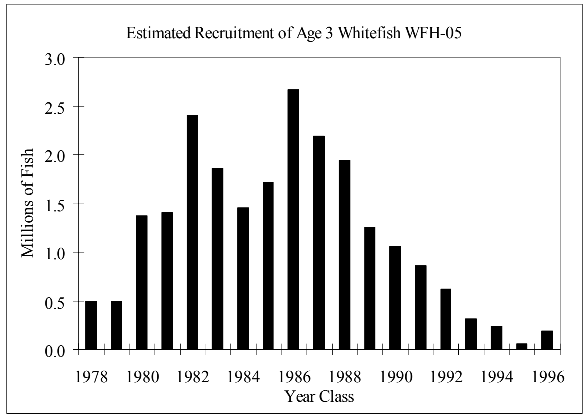
Annual commercial trap-net yields have ranged from 124,000 in the early 1980s to 724,000 lb in 1989 and averaged 355,000 lb during 1976-1999. Since 1991 the trap-net yield from WFH-05 has averaged 403,000 lb. Changes in the trap-net yield been related to changes in trap-net effort in WFH-05. As effort increased from less than 300 lifts in the early 1980s to 400-500 lifts in the late 1980s, yield also increased. The 65% reduction in trap-net effort from 1990 to 1991 produced a 51% reduction in yield from 1990 to 1991. As effort increased from 1991 to 1999 so did the yield.

Because of the 19-inch minimum size limit and limited fishery, whitefish from WFH-05 are larger than from stocks in other units of Lake Huron in the 1836 Treaty waters. The commercial yield is made up of roughly 50% No1 whitefish (<3 lb), 35% mediums (3-4 lb), and 15% jumbos (>4 lb) by weight.

Growth rate of whitefish has declined more in WFH-05 than most



other areas of Lake Huron in the 1836 Treaty waters. Mean weight-at-age has declined almost annually for whitefish from WFH-05 during 1981-1999 for nearly all age classes, while in the more northern units mean weight-at-age has stabilized or increased slightly during the late 1990s. Whitefish of ages 4, 5, 7, 8, and 9+ all weighed less in 1999 than in any other year during 1981-1999.
The declines in size-at-age have delayed the onset of sexual maturity in female whitefish. In the early 1980s many age 4-7 female whitefish were sexually mature, but by 1995 the proportion of age-4 to -7 fish that were sexually



mature had declined. The most noticeable declines in sexual maturity occurred at ages 5 and 6.

The stock assessment model estimated that recruitment of the 1993-1996 year classes was substantially less than for year classes prior to 1993. We estimated that very large year classes were produced in WFH-05 during 1982-1991 that ranged from 1.5 to 2.7 million at age 3. In comparison, the stock assessment model estimated that the 1993-1996 year classes contained only 61,000 to 314,000 fish. Recruitment at age 3 averaged 1.2 million fish from 1981 to 1999 and 874,000 fish during 1990 to 1999.

The predicted population and spawning stock biomass in WFH-05 have been declining since the early 1980s based on the stock assessment model. Biomass of whitefish ≥age 3 peaked at 9.1 million lb in 1992 then declined to only 1.9 million lb in 1999. Biomass of age-3 and older whitefish averaged 6.3 million lb during 1990-1999 and biomass of the spawning stock averaged 4.8 million lb in 1999. Spawning stock biomass peaked at 6.6 million lb in 1993 then declined.

As in the other Lake Huron management units, observed wounding data suggests that sea lamprey killed many whitefish in WFH-05. We estimated, using the stock assessment model, that an average of 70,000 whitefish were killed annually by sea lamprey during 1981-1999. Peak mortality occurred in 1993 when an estimated 124,000 fish were killed by sea lamprey.

Fishing mortality (F) on whitefish ≥age 4 peaked at 0.34 in 1986, but has been substantially less than that since then. Fishing mortality averaged only 0.15 during 1997-1999 and trap nets accounted for 94% of that mortality. Age-8 whitefish are the most vulnerable to the fishery and mortality on these fish was estimated to be 0.34 in 1999.

Total annual mortality was only 43% on whitefish ≥age 4 in WFH-05 in 1999, thus the projection model indicated that fishing mortality could be increased 2.2 times over the 1997-1999 level in 2001. Nevertheless, the projected yield with the spreadsheet model (229,000 lb)was substantially less than the average yield during 1997-1999, because of the estimated decline in recruitment during recent years. Therefore, the tribal harvest regulation guideline for 2001 was set equal to the average yield of 461,000 lb during 1997-1999. The average yield was used as a way to balance commercial fishers perceptions that WFH-05 has very abundant whitefish populations based on previous trap-net yields, and concerns about the future recruitment levels to the fishable stock.

Summary Status – WFH-05 lake whitefish	
Female maturity	
Length at first spawning	17 in
Age at first spawning	4 y
Length at 50% maturity	19 in
Age at 50% maturity	6 y
Spawning stock biomass per recruit	
Base SSBR	1.56 lb
Current SSBR	0.75 lb
SSBR at target mortality	0.37 lb
Spawning potential reduction	
At target mortality	0.36
Average yield per recruit	0.36 lb
Natural mortality (M)	0.32 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	7 y
Fully selected age to trap nets	8 y
Average gill net ages 4+	0.14 y^{-1}
Average trap net ages 4+	0.01 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0.05 y^{-1}
Total mortality rate (Z)	
Average 4+ 1997-1999	0.20 y^{-1}
Average 4+ 1999	0.56 y^{-1}
Average 4+ 2001	0.84 y^{-1}
Recruitment (age-3) (1990-1999 average)	874,000 fish
Biomass (age 3+) (1990-1999 average)	6,278,000 lb
Spawning biomass (1990-1999 average)	4,825,000 lb
Harvest regulation guideline in 2001	461,000 lb

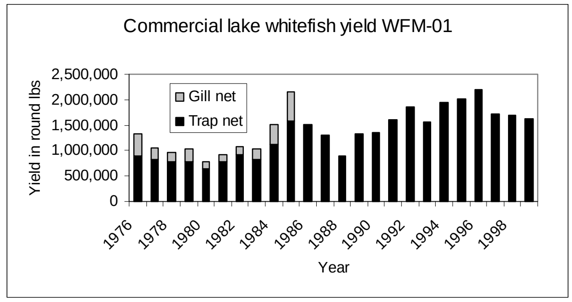
Lake Michigan

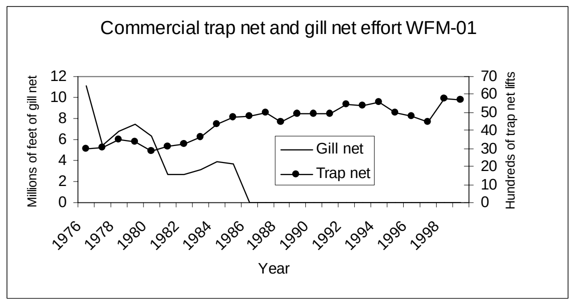
WFM-01 (Bays de Noc)

Prepared by Philip J. Schneeberger

Lake whitefish management unit WFM-01 is located in 1836 Treaty waters of northern Green Bay. Prominent features of this area include: two large bays (Big and Little Bays de Noc), numerous small embayments, several islands (including St. Martins Island, Poverty Island, Summer Island, Little Summer Island, Round Island, Snake Island, and St. Vital Island), as well as various shoal areas (Gravelly Island Shoals, Drisco Shoal, North Drisco Shoal, Minneapolis Shoal, Corona Shoal, Eleven Foot Shoal, Peninsula Point Shoal, Big Bay de Noc Shoal, Ripley Shoal, and shoals associated with many of the islands listed above). Little Bay de Noc is the embayment delineated by statistical grid 306. Its surface area is 39,880 acres. Shallow waters characterize the northern end and nearshore areas, but there is a 40- to 100-ft channel that runs the length of the bay. Rivers that flow into Little Bay de Noc include the Whitefish, Rapid, Tacoosh, Days, Escanaba, and Ford. Big Bay de Noc is a larger embayment of 93,560 acres delineated by statistical grids 308 and 309. Big Bay de Noc is relatively shallow with over half the area less than 30 ft deep and a maximum depth of 70 ft. Rivers that empty into Big Bay de Noc include the Big, Little, Ogontz, Sturgeon, Fishdam, and Little Fishdam.

Waters in WFM-01 (380,652 total surface acres) offer extensive areas where suitable habitat is available and is likely used by spawning whitefish. The

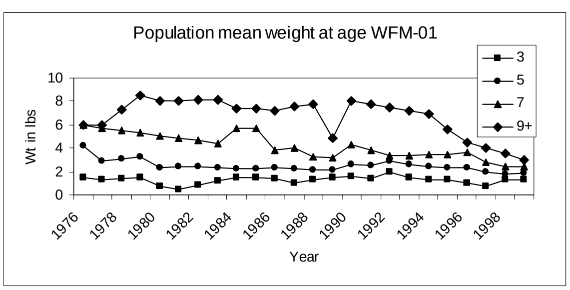




Big Bay de Noc Shoal is documented as being a very important area for lake whitefish reproduction. Conditions on this shoal are fairly consistently favorable resulting in relatively stable recruitment from year to year. It is speculated that stocks spawning in other areas of WFM-01 are mixed. The bay areas are important nursery grounds for whitefish larvae and fry.

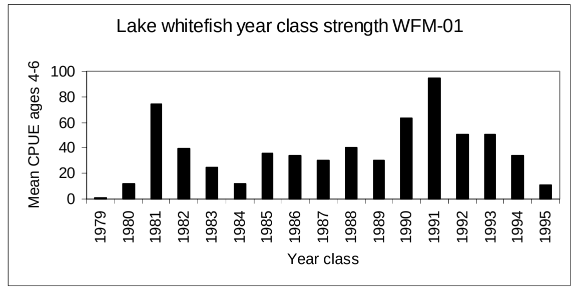
Lake whitefish in WFM-01 were harvested by gill nets and trap nets through 1985, and exclusively by state-licensed trap nets between 1986 and 1999. Between 1976 and 1999, yield of lake whitefish averaged 1,435,000 lb annually from WFM-01 with a minimum of 790,000 lb in 1980 and a maximum of 2,210,000 lb in 1996. This area had, by far, the highest yields of lake whitefish for state-licensed fishers in 1836 Treaty waters of Lake Michigan. It is also the location that had the highest number of active state licenses and the most fishing effort. As many as 25 different trap-net licenses were active in WFM-01 over the years; 17 were active during 1998. Fishing effort consisted of an average of 5,084 trap-net lifts per year between 1986 and 1999, and effort was basically stable during the period. Trap nets set under the ice in the Bays de Noc provide a winter fishery. State-licensed fishers in WFM-01 played an important role in the Consent Decree negotiations by offering to accept a buy out of their operations so that the area could be turned over to tribal fishing.

Length-at-age and weight-at-age are somewhat smaller for lake whitefish in WFM-01 compared to fish from other management zones with state-licensed fisheries. Most (84%) fish harvested from WFM-01 are less than 20 inches in total length and most (85%) are less than 6-yr old. Mean length of fish in catches has increased since the early 1990s, but average weight of fish has stayed relatively stable. Average age of fish in catches has increased as growth has slowed and smaller (but legal) fish have



been voluntarily culled during lifts in part due to market considerations associated with decreasing weight-at-length.

Strongest year classes were produced in 1981 and 1991, and moderate to



strong year classes were produced every year but 1984. Abundance of lake whitefish appears to be fairly stable in WFM-01 based on annual calculations of CPUE.

Biomass of the fishable stock of lake whitefish in WFM-01 averaged 7.03 million lb between 1990 and 1999. Annual biomass of the fishable stock increased from about 4.1 million lb in 1990 to a peak of 9.5 million lb in 1994, then declined to 4.5 million lb in 1999.

Average spawning stock biomass was 2.2 million lb between 1990 and 1999, or on average, 34% of the biomass available at the beginning of the year. Spawning stock biomass has fluctuated with a high close 1.9 million lb in 1992, a mid-period low of 1.5 million lb in 1994, and a rebound to 3.4 million lb in 1996, followed by a decline to 2.6 million lb in 1999. Spawning stock biomass is expected to trend back upwards in future years.

Trap-net fishing mortality (F) on lake whitefish aged 4 and older averaged 0.80 y^{-1} during 1997-99 and was high compared with rates in other management zones. Fishing mortality has been nearly this high (average 0.79 y^{-1}) throughout the 1990s in WFM-01.

Instantaneous total mortality rate (Z) was above the target rate at 1.19 y^{-1} during 1997-99. Trap-net effort should be decreased to 60% of the 1997-99 level according to the projection model. This reduced effort would produce an estimated yield of 796,000 lb. This is a reasonable goal considering the historically high fishing mortality rates produced from greater levels of effort.

Summary Status – WFM-01 lake whitefish	
Female maturity	
Size at first spawning	1.59 lb
Age at first spawning	4 y
Size at 50% maturity	1.87 lb
Age at 50% maturity	5 y
Spawning stock biomass per recruit	
Base SSBR	0.53 lb
Current SSBR	0.05 lb
SSBR at target mortality	0.08 lb
Spawning potential reduction	
At target mortality	0.15
Average yield per recruit	0.37 lb
Natural mortality (M)	0.38 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	NA
Fully selected age to trap nets	8 y
Average gill net ages 4+	NA
Average trap net ages 4+	0.80 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0 y^{-1}
Total mortality rate (Z)	
Average 4+ 1997-1999	1.19 y^{-1}
Average 4+ 1999	1.31 y^{-1}
Average 4+ 2001	0.87 y^{-1}
Recruitment (age-3) (1990-1999 average)	1,813,000 fish
Biomass (age 3+) (1990-1999 average)	7,028,000 lb
Spawning biomass (1990-1999 average)	2,238,000 lb
Recommended yield limit in 2001	796,000 lb

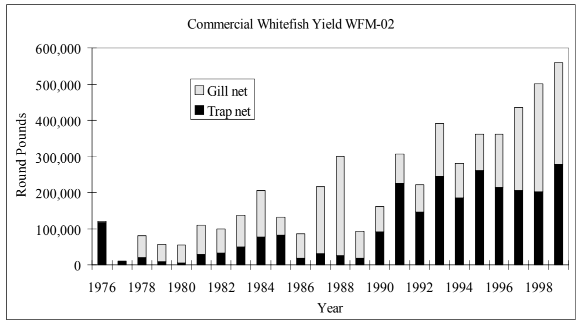
WFM-02 (Manistique Stock)

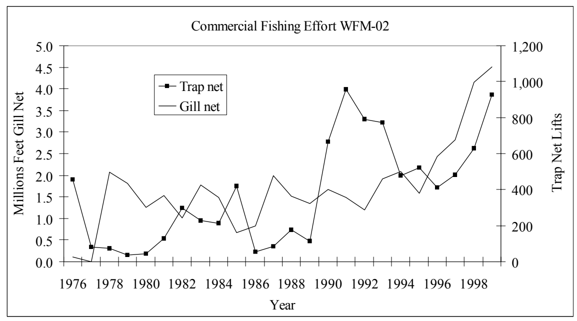
Prepared by Mark P. Ebener

WFM-02 is located in the northwest portion of Lake Michigan between Seul Choix Point and Point Detour. The unit is composed of 14 statistical grids, and 11 of these grids contain waters shallow enough to support whitefish. Out of a total of roughly 750,000 acres**,** there is 387,000 surface acres of water <240 ft. deep in the unit. The deepest part of WFM-02 is located in the southeast corner of the unit and is about 540 ft. deep.

The shoreline of WFM-02 lies within the Niagara Escarpment and is composed of dolomite limestone on the surface. The shoreline north of Pt. Detour and south of Pt. aux Barques is irregular with many small bays and rocky points. The only known spawning population of whitefish in WFM-02 is located in Portage Bay, but this population is not as abundant as other stocks in Lake Michigan. Many of the whitefish inhabiting WFM-02 move into the unit from other areas such as WFM-01, WFM-03, Wisconsin waters, and from the Beaver Island complex.

WFM-02 has been an exclusive tribal fishing zone since 1985. One trap-net operation and up to four large gill-net boats have regularly fished WFM-02. Very little small-boat gill-net effort occurs in this unit. Besides whitefish, the large-boat gill-net fishery in WFM-02 routinely targets bloaters in more offshore waters. The unit is known for being a “dirty” place to fish with large-mesh gill nets because logs, dead algae and dead periphyton, zebra mussels, and burbot routinely foul the gear.





The average commercial yield from WFM-02 was 220,000 lb from 1976 to 1999. The peak yield was 559,000 lb in 1999 and the lowest yield was 11,000 lb in 1977. During 1990-1999 the average yield was 358,000 lb. The long-term yield has been nearly equally split between trap nets and gill nets.

The increase in yield of whitefish from WFM-02 has been due to substantial increases in fishing effort. Large-mesh gill-net effort was greater in 1999 than any other year since 1976, while trap-net effort in 1999 was slightly less than the peak in 1991. In 1999, 4.5 million ft. of large-mesh gill net was set and there were 926 trap-net lifts.

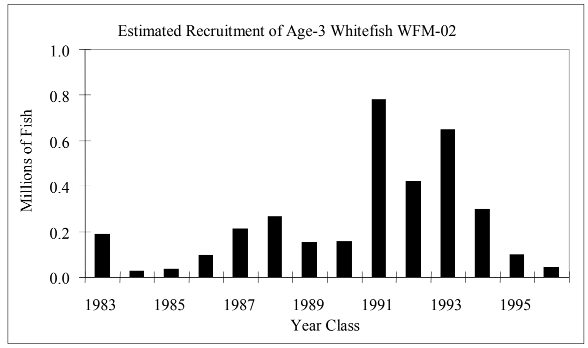
Whitefish in WFM-02 are of moderate size. The yield was made up of, by weight, 56% No1 (<3 lb) whitefish, 28% mediums (3-4 lb), and 16% jumbos (>4 lb) during 1986-1999.

The size structure shifted toward smaller fish from the early 1990s to the late 1990s. During 1986-1994 the proportion of the three commercial sizes of whitefish harvested was 50% No1, 30% medium, and 20% jumbo, while from 1995 to 1999 the proportion was 65% No1, 24% medium, and 11% jumbo. Mean weight in harvest ranged from 2.2 to 3.3 lb in the trap-net fishery and 2.5 to 3.8 lb in the gill-net fishery during 1986-1999.

As in many other units, growth of whitefish in WFM-02 has declined substantially through time. Mean weight at age of whitefish ≥age 4 has declined almost continually since 1986 and possibly earlier. Only mean weight of age 9 and older whitefish was greater in 1999 than some of the previous years in WFM-02. An age-8 whitefish weighed 4.7 lb in 1986-1987, but only 3.4 lb in 1998-1999.

The decline in growth rates has had a profound effect on sexual maturity of female whitefish in WFM-02. In the mid-1980s slightly more than 50% of age-3 and >90% of age-5 and older female whitefish were sexually mature in WFM-02. By 1999 only 18% of age-3, 50% of age-4, and 73% of age-5 female whitefish were sexually mature.

Estimated recruitment of age-3 whitefish to the fishable population in WFM-02 varied 27-fold during 1986-1999. Using the stock assessment model, we estimated that the 1991 year class contained 781,000 fish at age-3, compared to only 28,500 fish for the 1984 year class at age 3. Recruitment of age-3 whitefish to the fishable population averaged 245,000 fish during 1986-1999 and 308,000 fish during 1990-1999. If the low abundance of the 1995 and 1996 year classes estimated with the stock assessment model is accurate, then much reduced commercial yields can be expected in WFM-02



during 2001 and 2002.

Estimated biomass of whitefish in WFM-02 increased from 1986 through 1997, then declined substantially. The stock assessment model estimated that fishable stock biomass, increased from an average of 770,000 lb in 1986-1988 to 2.2 million lb during 1985-1997, then declined to an estimated 1.0 million lb in 1999. Fishable stock biomass of whitefish averaged 1.2 million lb during 1986-1999 and peaked at 2.4 million lb in 1997.

Sexually mature whitefish made up a substantial proportion of the total biomass in WFM-02. Spawning stock biomass ranged from 435,000 lb in 1989 to 1.75 million lb in 1995 and averaged 1.0 million lb during 1986-1999. Sexually mature whitefish made up 85% of the total biomass of whitefish ≥age 3 in WFM-02 during 1986-1999.

Fishing mortality (F), on whitefish ≥age 4 peaked at 1.05 in 1993 in WFM-02 and gill-net effort accounted for 57% of that mortality. The maximum gill-net mortality rate was 0.62 in 1999, while the maximum trap-net mortality rate was 0.46 in 1993. Fishing mortality averaged 0.76 during 1997-1999 and was 1.02 in 1999.

Total annual mortality, averaged over ages of whitefish ≥age 4 was slightly less than the target mortality rate of 1.05 during 1997-1999, however, the total annual mortality on fully vulnerable age-classes exceeded the maximum total mortality rate. Consequently, the projection model indicted that fishing effort should be decreased to 65% of that experienced during 1997-1999. The projected yield level at the target mortality rate (117,000 lb) was substantially less than yields during previous years. Consequently, the tribal harvest regulation guideline for 2001 was set to the average yield during 1997-1999 of 357,000 lb.

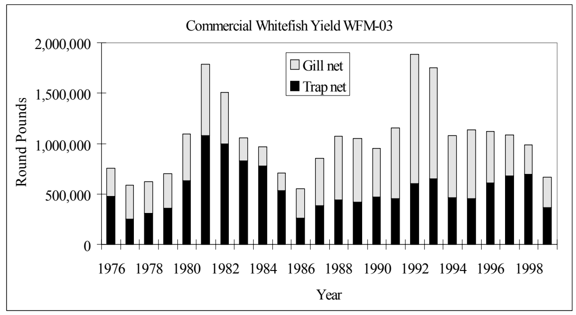
Summary Status – WFM-02 lake whitefish	
Female maturity	
Length at first spawning	16 in
Age at first spawning	3 y
Length at 50% maturity	18 in
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	3.61 lb
Current SSBR	0.75 lb
SSBR at target mortality	0.86 lb
Spawning potential reduction	
At target mortality	0.27
Average yield per recruit	0.99 lb
Natural mortality (M)	0.25 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	8 y
Fully selected age to trap nets	8 y
Average gill net ages 4+	0.51 y^{-1}
Average trap net ages 4+	0.25 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0 y^{-1}
Total mortality rate (Z)	
Average 4+ 1997-1999	1.01 y^{-1}
Average 4+ 1999	1.28 y^{-1}
Average 4+ 2001	0.74 y^{-1}
Recruitment (age-3) (1990-1999 average)	308,000 fish
Biomass (age 3+) (1990-1999 average)	1,412,000 lb
Spawning biomass (1990-1999 average)	1,150,000 lb
Harvest regulation guideline in 2001	357,000 lb

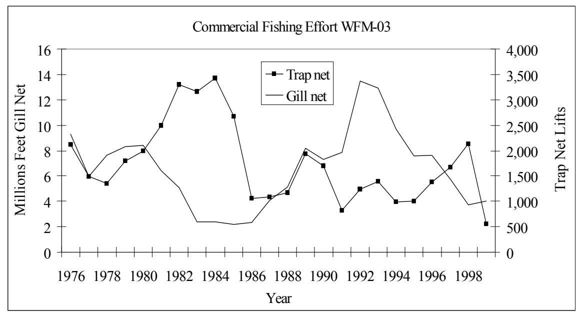
WFM-03 (Naubinway Stock)

Prepared by Mark P. Ebener

Unit WFM-03 is located in very northern Lake Michigan. The unit extends from the Straits of Mackinac west to Seul Choix and is bounded on the south by Beaver Island and the complex of shoals and islands than surround the island. Nearly all of WFM-03 contains shallow water less than 90 ft. deep, but a narrow 120-160 ft. trench runs east-west through the lower end of WFM-03 from the Straits of Mackinac to Seul Choix Point. The deepest point in WFM-03 is about 200 ft. deep and is located in the Straits of Mackinac. There are nine shallow shoals in WFM-03 scattered throughout the unit. Fourteen statistical grids make up WFM-03 and all of these grids contain shallow water. There is 483,000 surface acres of water <240 ft. deep in WFM-03, 100% of the total area in the unit.

This unit contains several very large spawning aggregations of whitefish. The entire northern shoreline of WFM-03 is part of the Niagara Escarpment and is composed of dolomite limestone on the surface, consequently, much of the whitefish spawning occurs throughout the northern shoreline. Large spawning aggregations are associated with the area between Epoufette and Naubinway, in the Straits of Mackinac from Pt. aux Chenes to the Mackinac Bridge, and in Cecil and Big Stone Bays along the northern lower Peninsula. The current boundaries for WFM-03 are based on a mark-recapture study of adult whitefish conducted by Michigan State University researchers near Naubinway in the late 1970s and early 1980s.



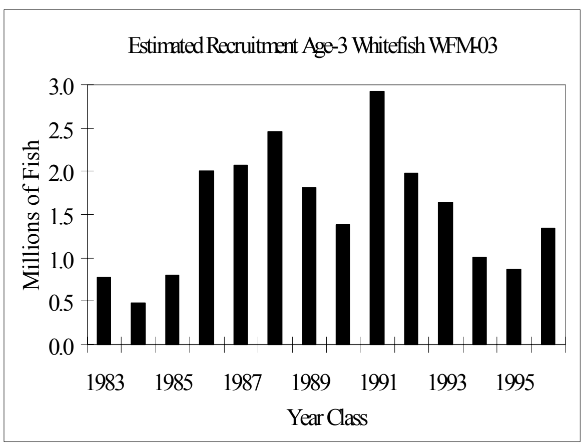


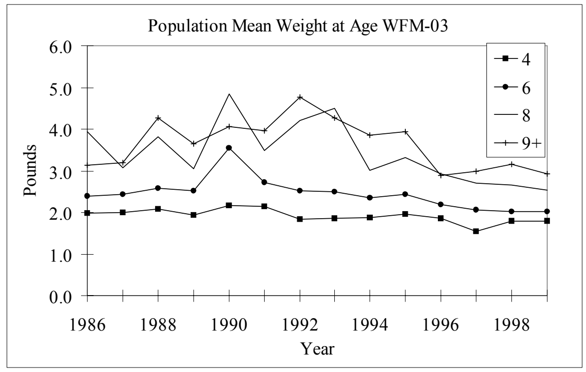
WFM-03 has been an exclusive fishing zone for the tribal fishery since 1985, and has been an important commercial fishing zone for whitefish for most of the twentieth century. A large state-licensed trap-net fishery operated in WFM-03 prior to 1985, and since 1985 the CORA yield of whitefish from WFM-03 was greater than from any of the other 13 exclusive tribal management units in the 1836 Treaty waters.

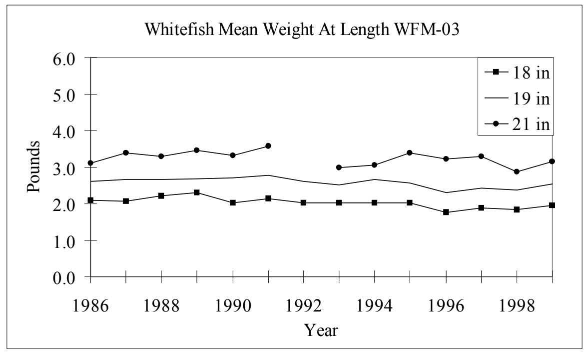
Both large and small gill-net boats and a trap-net fishery exist in WFM-03, but the majority of the yield is taken in the trap-net and large-boat gill-net fishery. The small-boat gill-net fishery is concentrated in the Straits of Mackinac and near Naubinway and Epoufette in the fall, whereas the large-boat gill- and trap-net fishery operates throughout WFM-03.

The commercial yield from WFM-03 averaged 1.05 million lb during 1976-1999. During this time period, the trap-net yield averaged 551,00 lb and the gill-net fishery 499,000 lb. The trap-net yield ranged from 254,000 lb in 1977 to 1.08 million lb in 1981. The gill-net yield ranged from 176,000 lb in 1985 to 1.3 million in 1992. The gill-net yield of whitefish has declined substantially since the mid-1980s and the 1998 and 1999 yields were only 289,000 and 302,000 lb, respectively. Conversely, the trap-net yield of whitefish has increased continually since the mid-1980s. The 1998 and 1999 trap-net yields were 698,000 and 366,000 lb respectively.

The commercial yield from WFM-03 appears to be influenced by both fishing effort and a cyclical pattern in recruitment. Peak commercial yields of 1.8 and 1.9 million lb occurred in 1981 and 1992, respectively, as the exceptional abundant 1977 and large 1986-1989 year classes entered the fishery during those years. As these abundant year classes entered the fishery, fishermen responded by increasing fishing effort. Peak trap-net effort was 3,300 lifts in 1984, while gill-net effort peaked at 13.5 million ft. in 1992 and 12.9 million ft. in 1993.







Whitefish in WFM-03 are of small size, with 84% of the yield (by weight) being composed of No1 fish (<3 lb) during 1996-1999. Medium whitefish (3-4 lb) made up 13% and jumbos (>4 lb) only 3% of the commercial yield from WFM-03 during 1986-1999. Annual mean weight of whitefish in the trap-net harvest was 2.3 lb and ranged from 2.1 to 2.6 lb during 1986-1999. Annual mean weight of whitefish in the gill-net harvest was 2.5 lb and ranged from 2.4 to 3.6 lb during 1986-1999.

As in most many other management units, growth of whitefish in WFM-03 has declined through time. Nearly all age classes of whitefish weighed less in 1998 and 1999 than any other time during 1986-1999. For example, prior to 1992 the mean weight of age-5 whitefish always exceeded 2.2 lb, by 1999 age-5 whitefish averaged 1.9 lb.

Condition of whitefish also declined in WFM-03. Mean weight at a given length declined from 1986 through about 1998 and recovered slightly thereafter, but not to the levels observed before 1998. Whitefish of 18-, 19-, and 21-inch long weighed 7-9% less after 1995 than prior to 1995. The declines in growth and condition do appear to correlate with the increased levels of recruitment observed during 1989-1995, and as recruitment and subsequent abundance has declined, condition has improved slightly.

The decline in growth has had an influence on sexual maturity of whitefish in WFM-03. Prior to 1990, 94% of age-3 and 98% of age-4 whitefish were sexually mature. After 1995 only 19% of age-3 and 73% of age-4 whitefish were sexually mature. Meanwhile, over 95% of age-5 whitefish have been sexually mature in WFM-03 during 1986-1999.

Estimated biomass of whitefish ≥age 3 at the beginning of each year averaged 6.3 million lb during 1986-1999. Annual biomass increased from a low of 3.9 million lb in 1988 to 8.4 million lb in 1995. Biomass of whitefish ≥age 3 was estimated to be 4.25 million lb in 1999.

Spawning stock biomass averaged 6.5 million lb, and generally declined from 1990 to 1999 as growth rates declined. Spawning stock biomass was fairly stable during 1990-1995 ranging from 7.3 to 8.6 million lb, after 1995 spawning stock biomass declined annually and reached it lowest level of 4.1 million lb in 1999.

Estimated fishing mortality (F) of whitefish ≥age 4 ranged from 0.19 to 0.62 during 1986-1999. Fishing mortality was lowest in 1986 and highest in 1993 on age-4 to -9+ whitefish. Estimated fishing mortality declined annually from 0.62 in 1993 to 0.21 in 1999. The gill-net fishery accounted for most the fishing-induced mortality during 1986-1999, except after 1997.

Total annual mortality rates on the fishable population of age-4 and older whitefish was less than the target rate during 1997-1999. The spawning potential reduction value at the target fishing mortality rate was 0.43, well above the minimum acceptable levels of 0.20. The projection model estimated that fishing mortality in 2001 could be increased roughly 1.6 times from the 1997-1999 level thus increasing total mortality to 65% on the most fully vulnerable age class of whitefish. The projection model estimated a yield at this mortality rate was 953,000 lb for WFM-03 in 2001, and this level was accepted as a recommended maximum yield by the TFC.

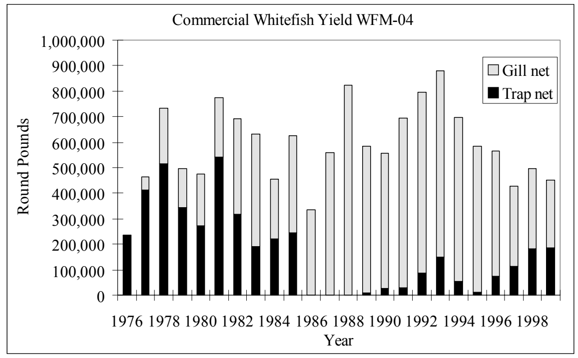
Summary Status – WFM-03 lake whitefish	
Female maturity	
Length at first spawning	14 in
Age at first spawning	3 y
Length at 50% maturity	16 in
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	2.08 lb
Current SSBR	1.07 lb
SSBR at target mortality	0.89 lb
Spawning potential reduction	
At target mortality	0.43
Average yield per recruit	0.57 lb
Natural mortality (M)	0.34 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	7 y
Fully selected age to trap nets	8 y
Average gill net ages 4+	0.12 y^{-1}
Average trap net ages 4+	0.20 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0 y^{-1}
Total mortality rate (Z)	
Average 4+ 1997-1999	0.66 y^{-1}
Average 4+ 1999	0.58 y^{-1}
Average 4+ 2001	0.84 y^{-1}
Recruitment (age-3) (1990-1999 average)	1,750,000 fish
Biomass (age 3+) (1990-1999 average)	3,200,000 lb
Spawning biomass (1990-1999 average)	3,100,000 lb
Recommended yield limit in 2001	953,000 lb

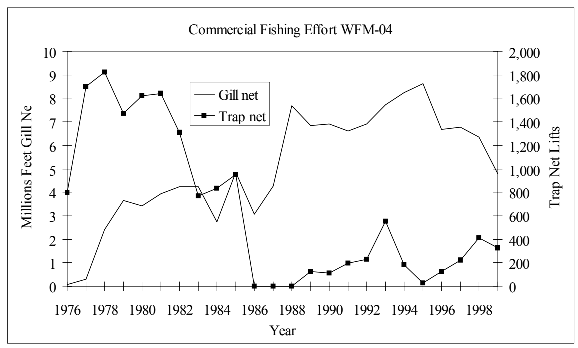
WFM-04 (Beaver Island Stock)

Prepared by Mark P. Ebener

Management unit WFM-04 is located in central northern Lake Michigan and contains a very diverse range of habitat. There are seven islands located in the unit; Beaver, Trout, High, Gull, Garden, Hog, and Isle aux Galets. These islands are all located along the northern edge of the unit and associated with a large, shallow, rocky reef complex that extends about 15 miles west from Waugoshance Point. The northern reef complex is shallow ranging from 5 to 30 ft. deep. To the south of this large reef complex are also located many smaller submerged reefs located on the east and west sides of Beaver Island. These reefs are surrounded by deep water and include Richards Reef, Gull Island Reef, Boulder Reef, Hog Island Reef, and Dahlia Shoal. The maximum depth in WFM-04 is about 500 ft. and this depth of water is located in the southwest corner of the unit. Twelve statistical grids make up WFM-04 and the unit contains 577,000 surface acres of water <240 ft. deep, out of a total of 620,000 acres.

There are at least several reproductively isolated stocks of lake whitefish that inhabit WFM-04 and most, if not all of these, are associated with the large northern reef complex. One stock spawns in Sturgeon Bay along the northeast side of the unit. Another stock is found at Hog Island based on a genetic study of whitefish in Lake Michigan conducted in the late 1970s by researchers from the University of Wisconsin - Stevens Point. There are probably several other spawning stocks located in WFM-04 associated with Beaver Island and some of the other islands.





WFM-04 has been an exclusive commercial fishing zone for the tribal fishery since 1985, but much of the unit is designated as either a lake trout refuge or primary lake trout rehabilitation zone. The primary rehabilitation zone was located on the east and north sides of Beaver Island, while the areas south and west of Beaver Island make up the refuge. Retention of lake trout by sport or commercial fisheries is prohibited in the refuge. Grids 317-318 and 417-418 to the east of Beaver Island and west of the lower Peninsula of Michigan were designated as deferred rehabilitation zones where no limits were placed on the harvest of lake trout by the commercial fishery.

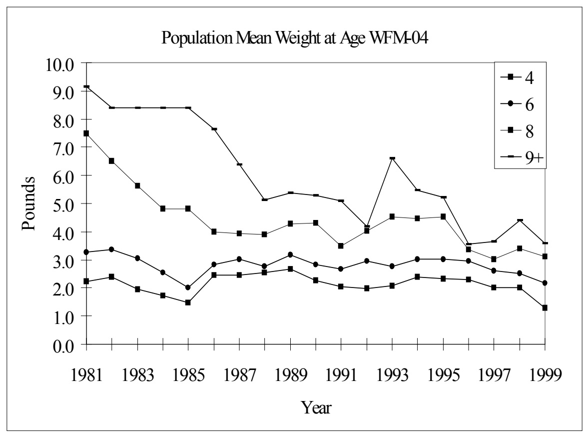
The eastern portion of WFM-04 along the Upper Peninsula of Michigan is a favorite fishing area for small-boat fisheries, while the more offshore waters of WFM-04 around Beaver Island are exclusive fishing grounds for large-boat gill- and trap-net fisheries. Only trap-net fisheries harvest whitefish from within the refuge.

Commercial yield of whitefish from WFM-04 has ranged from a low of 335,000 lb in 1986 to 881,000 lb in 1992 and averaged 585,000 lb during 1976-1999. The commercial yield was 451,000 lb in 1999; 187,000 lb in the trap-net fishery and 264,000 lb in the gill-net fishery. Since the 1985 Consent Order, the large-mesh gill-net fishery has accounted for the majority of the yield in WFM-04, but the lowest gill-net yield occurred in 1999.

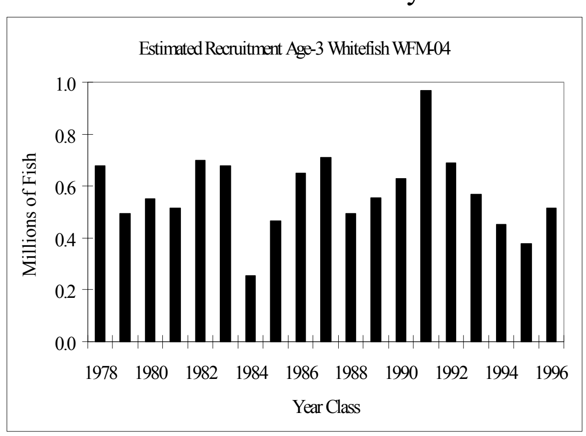
Trap-net effort has declined substantially in WFM-04 since 1976, while gill-net effort has increased. Trap-net effort declined from an average 1,600 lifts during 1977-1981 to less than 600 lifts during 1986-1999. Trap-net effort has been variable, yet without trend, between 1989 and 1999. Gill-net effort increased substantially from about 3.5 million ft annually during 1979-1987 to 7.0 million ft. annually during 1988-1998. Commercial fishing effort in 1999 was made up of 327 trap-net lifts and 4.8 million ft of large-mesh gill net.

Whitefish living in WFM-04 are of moderate size. During 1985-1999 No1 size (<3 lb) whitefish made up 57% of the harvest by weight, followed by mediums (3-4 lb) at 25%, and jumbos (>4 lb) at 17%. Annual mean weight of whitefish in the harvest ranged from 2.1 to 3.3 lb in the trap-net fishery and 2.6 to 3.5 lb in the gill-net fishery during 1985-1999. Mean weight of whitefish has averaged 2.6 lb in the trap-net fishery and 2.8 lb in the gill-net fishery during 1985-1999.

As in most other areas of Lake Michigan growth of whitefish in WFM-04 has declined substantially over the years, and the decline in growth has been most evident in the weight-at-age of older whitefish. Mean weight of an age-8 whitefish declined from 7.0 lb in the early 1980s to 3.3 lb in 1998-1999. Mean weight of age-4 and age-6 whitefish has been more stable than for other fish, yet both these age-classes weighed less in 1999 than in all other years during 1981-1999.



Estimated recruitment of age-3 whitefish to the population in WFM-04 has been more stable than most of stocks of whitefish in the 1836 Treaty waters.



The stock assessment model estimated that an average of 576,000 age-3 whitefish recruited to the population during 1981-1999. Recruitment varied from 253,000 for the 1984 year class to 968,000 for the 1991 year class. Most other year classes varied between 500,000 and 700,000 fish during 1981-1999. The 1996 year class was estimated to contain 514,000 fish when it recruited to the population in 1999.

The declines in growth have also reduced the rate of sexual maturity of whitefish in WFM-04. All female whitefish >age 6 were sexually mature prior to 1985, but since then no age class has achieved complete maturity. During 1981-1995, 27-57% of age-3 female whitefish were sexually mature, but during 1996-1999 only 10% of age-3 female whitefish were mature. The proportion of sexually mature age-4 female whitefish declined from an average of 83% prior to 1996 to 69% after 1996.

Estimated biomass of whitefish in WFM-04 was also remarkably stable during 1981-1999 compared to other management units. The stock assessment model estimated that biomass of whitefish ≥age 3 at the beginning of each year ranged from 2.1 million lb in 1984 to 3.9 million lb in 1995, and averaged 2.9 million lb during 1981-1999. The fishable stock biomass declined annually from 1995 to 1999 and was estimated to be 2.3 million lb in 1999. Spawning stock biomass averaged 2.9 million lb during 1981-1999 and peaked at 4.0 million lb in 1995. The spawning stock biomass was estimated to be 1.9 million lb in 1999 and was lower than all other years during 1981-1999.

The large-mesh gill-net fishery accounted for the majority of fishing mortality in WFM-04 during 1981-1999. Fishing mortality (F) on age-4 and older whitefish induced by the large-mesh gill-net fishery averaged 0.21 during 1997-1999 compared to 0.09 for the trap-net fishery. Gill net-induced fishing mortality ranged from 0.16 in 1999 to 0.43 in 1994. Trap-net mortality ranged from zero during 1986-1988 to 0.62 in 1981. Fishing mortality due to the trap-net fishery was 0.09 in 1999.

Total annual mortality on the fishable stock of whitefish in WFM-04 was substantially less than the target rate during 1997-1999. Total annual mortality of whitefish in WFM-04 averaged only 42% during 1997-1999. The spawning potential reduction (SPR) value at the current fishing rate is 0.38 and well above minimum acceptable SPR of 0.20. The projection model indicted that fishing-induced mortality could be increased 1.9 times in 2000 from the average fishing rate during 1997-1999. The yield for WFM-04 under this increased rate of fishing would be 590,000 lb, and this was accepted as the TFC recommended maximum yield in 2001. Given the stable levels of recruitment and low mortality a yield of 590,000 lb seems reasonable for WFM-04.

Summary Status – WFM-04 lake whitefish	
Female maturity	
Length at first spawning	15 in
Age at first spawning	3 y
Length at 50% maturity	17 in
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	3.13 lb
Current SSBR	1.19 lb
SSBR at target mortality	0.83 lb
Spawning potential reduction	
At target mortality	0.265
Average yield per recruit	0.84 lb
Natural mortality (M)	0.25 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	8 y
Fully selected age to trap nets	8 y
Average gill net ages 4+	0.21 y^{-1}
Average trap net ages 4+	0.09 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0 y^{-1}
Total mortality rate (Z)	
Average 4+ 1997-1999	0.55 y^{-1}
Average 4+ 1999	0.56 y^{-1}
Average 4+ 2001	0.82 y^{-1}
Recruitment (age-3) (1990-1999 average)	596,000 fish
Biomass (age 3+) (1990-1999 average)	3,144,000 lb
Spawning biomass (1990-1999 average)	3,019,000 lb
Recommended yield limit in 2001	590,000 lb

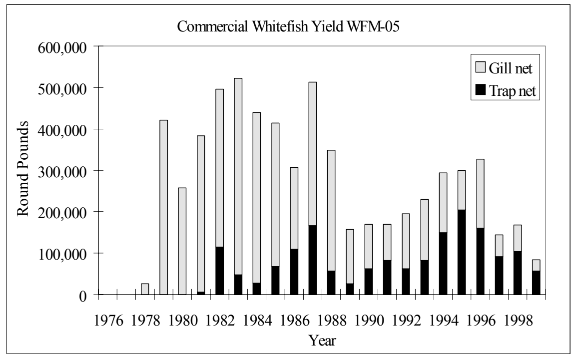
WFM-05 (Grand Traverse Bay Stock)

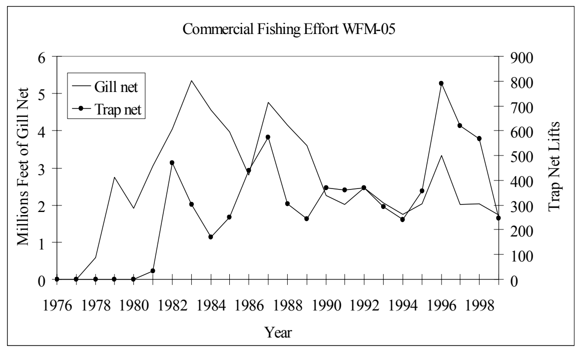
Prepared by Mark P. Ebener

Management unit WFM-05 encompasses the area from Little Traverse Bay through Grand Traverse Bay and offshore waters of Lake Michigan north and west of the Leelanau Peninsula. Much of WFM-05 contains water >240 ft. deep including the both the east and west arms of Grand Traverse Bay. The deepest parts of WFM-05 exceed 600 ft. in the offshore waters west of the Leelanau Peninsula, although several small shallow reef areas are located in these offshore waters and there is also an extensive shallow water area associated with the Fox Islands. Seventeen statistical grids make up WFM-05, but only 488,000 surface acres, or 46% of the water in these grids, is less <240 ft. deep. Much of the offshore waters of WFM-05 are part of the northern Lake Michigan lake trout refuge.

There are at least four reproductively isolated stocks of lake whitefish that inhabit WFM-05. Discrete spawning stocks of whitefish are found in both the east and west arms of Grand Traverse Bay, and in the outer Bay associated with Northport Bay based on mark-recapture studied conducted by Michigan State University researchers. There probably is another spawning stock of whitefish associated with the Fox Islands based on size and age structure of fish caught at the islands. Another, but smaller, spawning stock is likely found in Little Traverse Bay.

WFM-05 has been an important tribal fishing area since the 1970s. Much of the tribal fishing activity that





occurred prior to and immediately after re-affirmation of treaty-reserved fishing rights took place in Grand Traverse Bay. CORA small-boat fishermen relied on Grand Traverse Bay as an important fishing ground because the Bay contains deep water located close to shore, and because it offers small-boat fishermen protection from wind and waves. WFM-05 has been an exclusive tribal commercial fishing zone since 1985 and WFM-05 waters of Grand Traverse Bay have been an exclusive commercial fishing area for the Grand Traverse Band since 1985.

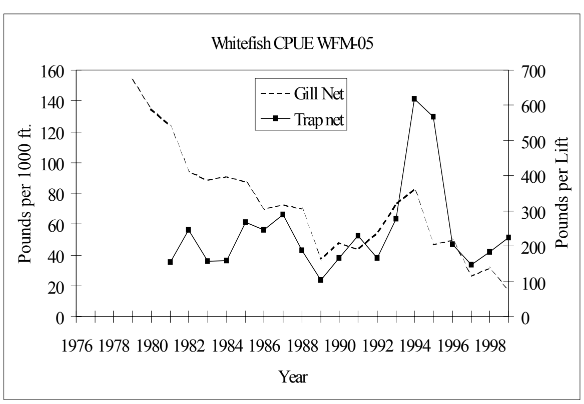
Initial tribal fishing activities in WFM-05 were focused on an exploited population of whitefish. Commercial fishing by state-licensed fisheries had been prohibited in WFM-05 for several decades before tribal small-boat fishermen began fishing the area in the late 1970s. Initial yields in 1978 and 1979 were in excess of 400,000 lb and jumbo (>4 lb) whitefish made up more than 90% of the yield. Harvests increased to >500,000 lb in 1983 and 1984, but by then jumbo whitefish made up only 30% of the yield.

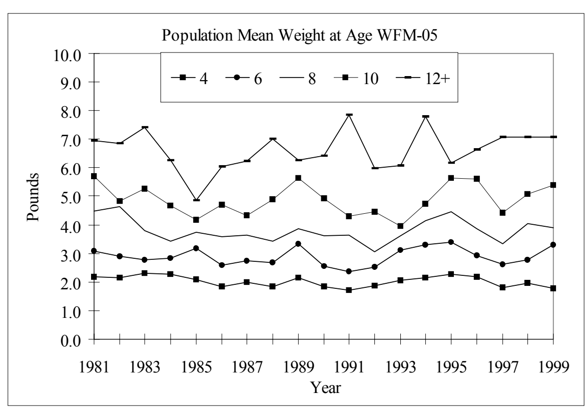
Commercial yields of lake whitefish were substantially less during the decade of the 1990s than during the 1980s. The commercial yield averaged 384,000 lb during 1980-1989 and 208,000 lb during 1990-1999. The 1999 yield was the lowest recorded at only 85,000 lb. Since 1994 the trap-net fishery has accounted for the majority of the yield in WFM-05, whereas prior to 1994 the large-mesh gill-net yield exceeded the trap-net yield in every year.

Gill-net effort in WFM-05 declined almost every year since 1984, whereas trap-net effort has varied, but without consistent trends upward or downward. Gill-net effort declined from 5.4 million ft. in 1983 to only 1.7 million ft. in 1999. Trap-net effort has varied annually between 200 and 800 lifts during 1982-1999. Trap-net effort in 1999 was 247 lifts.

The decline in yield of whitefish in WFM-05 has mirrored the decline in gill-net effort because of an apparent decline in catchability of whitefish to the large-mesh gill-net fishery. CPUE of whitefish in the large-mesh gill-net fishery declined from 153 lb per 1,000 ft. of gill net in 1979 to 17 lb per 1000 ft. of gill net in 1999. On the other hand, CPUE of whitefish in the trap-net fishery has been remarkably stable between 150 and 300 lb per lift, except for 1994 and 1995, during 1981-1999. Gill-net fishermen in WFM-05 claim the decline in catchability is because the gill nets commonly become coated with a slime that makes the net highly visible to whitefish. Whatever the cause, it is obvious that something is reducing catchability of whitefish to the large-mesh gill-net fishery in the unit.

Whitefish from WFM-05 are of moderate to large size. The proportion of the yield made up of the three sizes of whitefish was 54% No1 (<3 lb), 26% medium (3-4 lb), and 20% jumbo during 1979-1999. As illustrated earlier, size structure of whitefish in the yield from WFM-05 has changed over time, as the proportion of jumbos declined and the proportion of No1 whitefish increased. Annual mean weight of whitefish sampled from trap-net harvests ranged from 2.0 to 3.6 lb and averaged 2.8 lb during 1981-1999. Annual mean weight

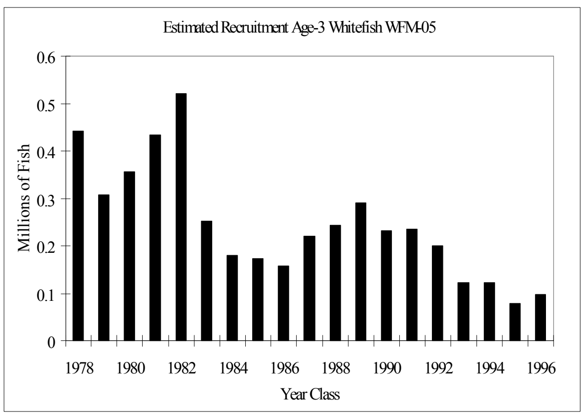




of whitefish in the gill-net harvest ranged from 2.4 to 3.5 lb and averaged 3.0 lb during 1981-1999.

Growth of whitefish from WFM-05 has remained very stable through the years, unlike the pattern of declining growth seen in other areas of Lakes Michigan and Huron, including substantial declines in areas adjacent to this management unit. Mean weight of ages 4-12+ whitefish showed no trends through time in WFM-05 from 1981 to 1999, although some age classes did weigh slightly less in 1999 than in 1981.

Recruitment of age-3 whitefish to the population in WFM-05 was highly



variable and has declined lately based on estimates from the stock assessment model. The number of age-3 whitefish entering the population each year was estimated to average 314,000 during 1981-1989, but only 184,000 during 1990-1999. The 1978-1983 year classes were estimated to range from 252,000 to 520,000 fish, while the 1990-1996 year classes ranged from 97,000 to 231,000 fish. It is difficult to assess whether the decline in recruitment is real, or an artifact of changing catchability to the gill-net fishery.

Biomass of whitefish estimated with the stock assessment model declined in response to declines in recruitment. Annual biomass of whitefish $\geq$age 3 at the beginning of each year peaked at 2.7 million lb in 1982, declined to 1.2 million lb in 1989, increased slightly to 1.7 million lb in 1994, then declined further to 636,000 lb in 1999. Spawning stock biomass also followed the same trend peaking at 2.8 million lb in 1982 and declining to 634,000 lb in 1999.

Fishing mortality (F) in WFM-05 was split about equally between the gill- and trap-net fishery in recent years. Average fishing-induced mortality on whitefish $\geq$age 4 averaged 0.12 for the large-mesh gill-net fishery and 0.16 for the trap-net fishery during 1997-1999. Gill net-induced fishing mortality ranged from 0.09 in 1999 to 0.36 in 1984, while trap-net-induced fishing mortality ranged from 0.01 in 1981 to 0.22 in 1996.

Total annual mortality on the fishable stock in WFM-05 during 1997-1999 was substantially less than the target rate of 65%. Total annual mortality was estimated to be 42% during 1997-1999 and the spawning potential reduction value was 0.36. Consequently, the projection model estimated that fishing mortality could be increased 2.1 times in WFM-05 in 2001 from the average value during 1997-1999. The projected yield associated with this level of fishing was 235,000 lb, and was accepted as the recommended maximum yield in 2001.

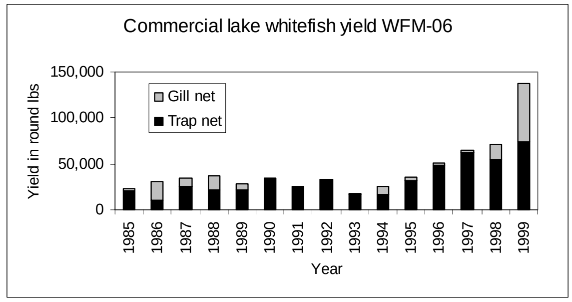
Summary Status – WFM-05 lake whitefish	
Female maturity	
Length at first spawning	NA
Age at first spawning	3 y
Length at 50% maturity	NA
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	4.35 lb
Current SSBR	1.56 lb
SSBR at target mortality	0.74 lb
Spawning potential reduction	
At target mortality	0.17
Average yield per recruit	1.02 lb
Natural mortality (M)	0.27 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	6 y
Fully selected age to trap nets	8 y
Average gill net ages 4+	0.12 y^{-1}
Average trap net ages 4+	0.16 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0 y^{-1}
Total mortality rate (Z)	
Average 4+ 1997-1999	0.55 y^{-1}
Average 4+ 1999	0.44 y^{-1}
Average 4+ 2001	0.87 y^{-1}
Recruitment (age-3) (1990-1999 average)	184,000 fish
Biomass (age 3+) (1990-1999 average)	1,248,000 lb
Spawning biomass (1990-1999 average)	1,015,000 lb
Recommended yield limit in 2001	235,000 lb

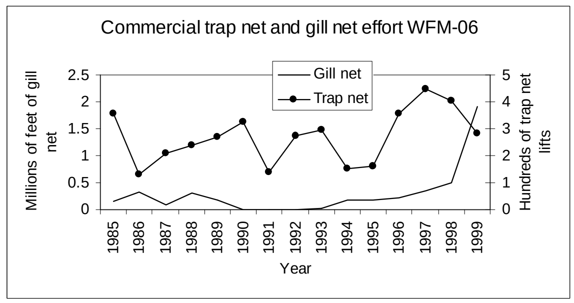
WFM-06 (Leland)

Prepared by Philip J. Schneeberger

Lake whitefish management unit WFM-06 is located in 1836 Treaty waters west of the Leelanau Peninsula from about Cathead Point south to Arcadia. Surface area for this unit is 945,156 acres and includes part or all of grids 709-714, 808-814, 908-912, and 1008-1011. These waters of Lake Michigan include Good Harbor Bay, Sleeping Bear Bay, and Platte Bay. Two large islands, North Manitou and South Manitou, are contained in this management zone, as are three large shoal areas including North Manitou Shoal, Pyramid Point Shoal, and Sleeping Bear Shoal. Major rivers flowing into WFM-06 include the Platte, and the Betsie. Betsie Lake is a drowned river mouth formed where the Betsie River flows into Lake Michigan. Except for areas near shore or around the islands, most of the waters in WFM-06 are deep (>200 ft). Bays, islands, and shoal areas offer the best habitat for lake whitefish spawning in this management area. Most trap-net effort and harvest is reported from grids 812 to 814 and 912 (areas associated with bays).

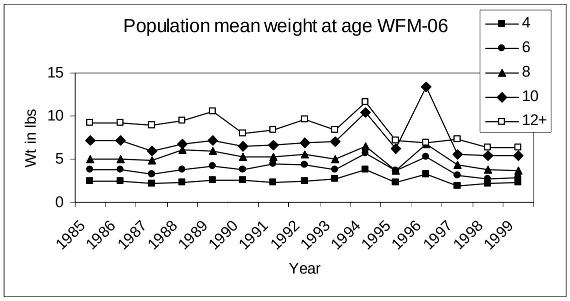
WFM-06 was reserved for state-licensed commercial trap-net fishing operations from 1985 through 1999, except that tribal gill netting was allowed in grid 714. The Consent Decree changed this to a shared zone, although there has been no tribal commercial fishing since this change. This unit is the least productive management zone for state-licensed fishers in 1836 Treaty waters of Lake Michigan. It also has the least number of active state licensees and the least fishing effort. Although three different licensed fishing operations have historically harvested whitefish from WFM-06, only one has remained active since 1983. Fishing for lake whitefish is generally curtailed in July during most years when the licensee opts to switch to fishing for chubs using gill nets.





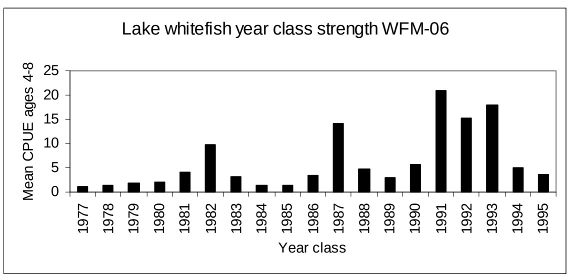
Catches from trap nets dominated the yield between 1990 and 1998, but yields by gill nets and trap nets were roughly equal in 1999, due in large part to a sharp increase in gill-net effort that year. Trap-net effort has fluctuated, averaging 269 lifts per year. Overall, yield has trended upward, increasing more than 300% from 34,000 lb in 1990 to 137,000 lb in 1999.

Length-at-age and weight-at-age for lake whitefish in WFM-06 are intermediate compared to those in WFM-01 and WFM-08. Fish between



17 and 23 inches (4-6 yrs old) compose the bulk (~80%) of the catch from WFM-06, but larger, older fish are well represented. During the last 5-10 years average length and weight of fish in catches have decreased but average age has increased. These trends reflect decreased growth over the period.

Stronger than average year classes were produced in WFM-06 from 1991



through 1993. Evaluation of subsequent year classes is not complete to date. Presumably, fish of catchable ages from these more recent year classes are still numerous in the extant population. Modeling estimated average recruitment of age-3 lake whitefish was 88,000 fish for 1990-99, much lower than for other management areas.

Average biomass of lake whitefish age 3 or older was 698,000 lb for 1990-99. Biomass ranged from 521,000 lb in 1992 to 921,000 lb in 1996.

Spawning stock biomass was relatively consistent between 1990 and 1999, averaging 643,000 lb. During this period, spawning stock biomass represented 94% of the available lake whitefish biomass in WFM-06.

Trap netting exerted a fishing mortality rate (F) of 0.18 y^{-1} on the population, compared to only 0.08 y^{-1} by gill netting. Fishing mortality from trap nets ranged from 0.05 y^{-1} in 1993 to 0.20 y^{-1} in 1999. Excluding years when there was no gill netting, fishing mortality from gill nets averaged only 0.02 y^{-1} during 1990-1998, then jumped to 0.18 y^{-1} in 1999.

Instantaneous total annual mortality rate (Z) averaged 0.58 y^{-1} for 1997-99, well below the maximum target rate of 1.05 y^{-1}. The 1999 Z value was estimated at 0.70 y^{-1} and the projection model indicated that trap-net effort could increase 1.11 fold and gill-net effort could increase by a factor of 5.20 to achieve a 2001 yield of 151,000 lb and a Z value of 0.95 y^{-1}.

Summary Status – WFM-06 lake whitefish	
Female maturity	
Size at first spawning	0.95 lb
Age at first spawning	3 y
Size at 50% maturity	2.10 lb
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	1.52 lb
Current SSBR	0.66 lb
SSBR at target mortality	0.37 lb
Spawning potential reduction	
At target mortality	0.24
Average yield per recruit	0.37 lb
Natural mortality (M)	0.31 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	6 y
Fully selected age to trap nets	7 y
Average gill net ages 4+	0.08 y^{-1}
Average trap net ages 4+	0.18 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0 y^{-1}
Total mortality rate (Z)	
Average 4+ 1997-1999	0.58 y^{-1}
Average 4+ 1999	0.70 y^{-1}
Average 4+ 2001	0.95 y^{-1}
Recruitment (age-3) (1990-1999 average)	88,000 fish
Biomass (age 3+) (1990-1999 average)	698,000 lb
Spawning biomass (1990-1999 average)	643,000 lb
Recommended yield limit in 2001	151,000 lb

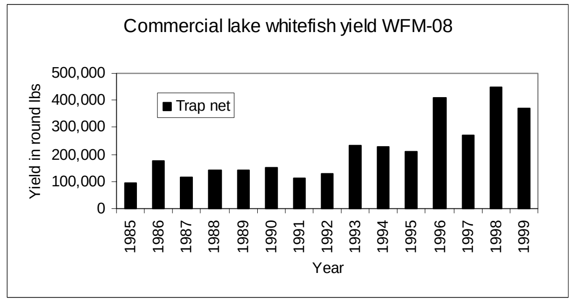
WFM-08 (Muskegon)

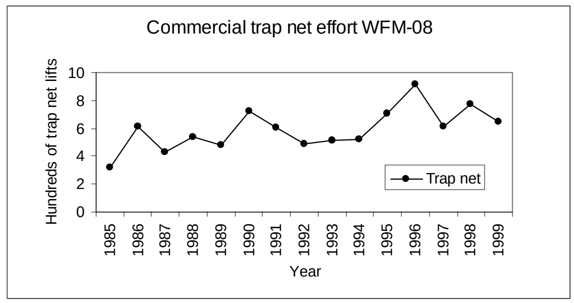
Prepared by Philip J. Schneeberger

Management unit WFM-08 is the Lake Michigan whitefish zone from about Montague south past Port Sheldon. WFM-08 has a surface area of 1,506,880 acres in Michigan grids 1706-1710, 1806-1810, 1906-1911, and 2006-2011. Apart from the shoreline, inflows from the White, Muskegon, and Grand rivers, and drowned river mouths at White, Muskegon, Mona, and Pigeon lakes, this area has few other distinguishing features relevant to lake whitefish biology. Depth gradients west from shore are relatively gradual, but most of the waters in WFM-08 are 200-ft deep or deeper. More than three quarters of the trap-net effort and over 80% of the trap-net harvest is reported from grid 1810.

Although commercial exploitation and monitoring have transpired for many years, little is known about reproductive biology of the WFM-08 lake whitefish stock. Fish in this area are near the southern end of the distribution for lake whitefish.

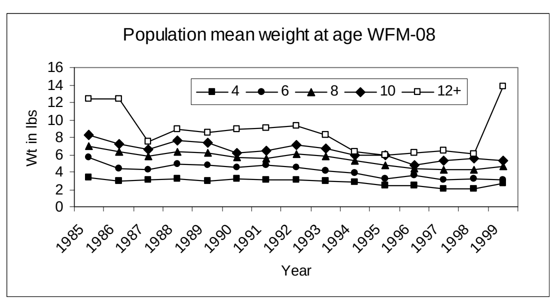
Since 2000, WFM-08 has been a shared zone, although there has been no tribal commercial fishing. Two state-licensed trap-net fishers operate in WFM-08 where minimum length for whitefish in commercial catches is 19 rather than 17 inches as in other management zones. The larger minimum length in WFM-08 but has biological implications such as a higher average number of spawnings per female. From 1985 through 1999 there was no gill-net harvest of lake whitefish in WFM-08.





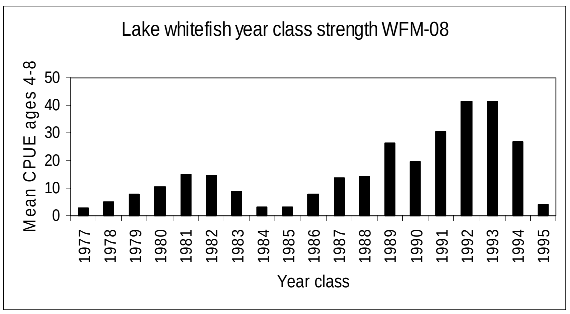
Yield by trap nets has trended upwards from 1985 to 1999. Average yield was 216,000 lb for the period, with a minimum harvest of 94,000 lb in 1985 and a maximum of 449,000 lb in 1998. Effort has increased gradually from 320 lifts in 1985 to 918 lifts in 1996 and averaging 592 lifts per year for 1985-99.

Length-at-age and weight-at-age for lake whitefish are greater in WFM-08 than in WFM-06 and WFM-01. Ninety percent of the harvested fish measure between 19 and 25 inches and although ages 5 and 6 make up more than half the



catch, fish aged 4, 7, and 8 are also prominent in catches. Mean length and mean weight of commercially caught whitefish have declined since the late 1980s, but mean age has varied without trend.

Lake whitefish year-class strength was consistently stronger from 1989 through 1994 than during the late 1970s through the mid-1980s. Two particularly strong consecutive year classes were produced in 1992 and 1993. Average recruitment of age-3 lake whitefish to the fishable stock during the 1990s was over 1.5 million fish according to the stock assessment model.



Biomass of the fishable lake whitefish stock at the start of the fishing seasons from 1990 through 1999 averaged nearly 6.28 million lb. Annual biomass of the fishable stock increased steadily from 3.5 million lb in 1990 to 7.5 million lb in 1999.

Spawning stock biomass had virtually the same range as fishable biomass and averaged 5.9 million lb during 1990-99. These exceptionally high values for spawning stock biomass are due to the higher minimum length for commercial retention and relatively light exploitation in WFM-08.

Fishing mortality (F) from trap nets on whitefish age 4 and older averaged 0.06 y^{-1} for 1997-99. Instantaneous total mortality rate (Z) for these same fish averaged 0.44 y^{-1}.

Based on the projection model, the lake whitefish stock in WFM-08 can support a nine-fold increase in trap-net effort. The projected yield under a regime of increased effort would be 3.3 million lb. The Consent Decree stipulates that state licensed fishers are allotted 45% of the quota or 500,000 lb, whichever is less.

Summary Status – WFM-08 lake whitefish	
Female maturity	
Size at first spawning	0.75 lb
Age at first spawning	3 y
Size at 50% maturity	2.28 lb
Age at 50% maturity	4 y
Spawning stock biomass per recruit	
Base SSBR	1.32 lb
Current SSBR	1.04 lb
SSBR at target mortality	0.45 lb
Spawning potential reduction	
At target mortality	0.34
Average yield per recruit	0.14 lb
Natural mortality (M)	0.37 y^{-1}
Fishing mortality rate (F) 1997-1999	
Fully selected age to gill nets	NA
Fully selected age to trap nets	8 y
Average gill net ages 4+	NA
Average trap net ages 4+	0.06 y^{-1}
Sea lamprey mortality (ML)	
Age 4+ 1997-1999	0 y^{-1}
Total mortality rate (Z)	
Average 4+ 1997-1999	0.44 y^{-1}
Average 4+ 1999	0.43 y^{-1}
Average 4+ 2001	0.94 y^{-1}
Recruitment (age-3) (1990-1999 average)	1,547,000 fish
Biomass (age 3+) (1990-1999 average)	6,277,000 lb
Spawning biomass (1990-1999 average)	5,861,000 lb
Recommended yield limit in 2001	3,305,000 lb